Coupled-channel study of crypto-exotic baryons with charm

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Identifying a zero-range exchange of vector mesons as the driving force for the s-wave scattering of pseudo-scalar mesons off the baryon ground states, a rich spectrum of molecules is formed. We argue that chiral symmetry and large-N_c considerations determine that part of the interaction which generates the spectrum. A bound state with exotic quantum numbers is predicted at mass 2.78 GeV. It couples strongly to the $(\bar{D}_s\, N), (\bar{D}\,\Lambda), (\bar{D}\,\Sigma)$ channels. A further charm minus-one system is predicted at mass 2.84 GeV as a result of $(\bar{D}_s \Lambda), (\bar{D}\,\Xi)$ interactions. We suggest the existence of strongly bound crypto-exotic baryons, which contain a charm-anti-charm pair. Such states are narrow since they can decay only via OZI-violating processes. A narrow nucleon resonance is found at mass 3.52 GeV. It is a coupled-channel bound state of the $(\eta_c\, N), (\bar{D}\,\Sigma_c)$ system, which decays dominantly into the $(\eta' N)$ channel. Furthermore two isospin singlet hyperon states at mass 3.23 GeV and 3.58 GeV are observed as a consequence of coupled-channel interactions of the $(\bar{D}_s\, \Lambda_c), (\bar{D}\,\Xi_c)$ and $(\eta_c\, \Lambda), (\bar{D}\,\Xi'_c)$ states. Most striking is the small width of about 1 MeV of the lower state. The upper state may be significantly broader due to a strong coupling to the $(\eta' \Lambda)$ state. The spectrum of crypto-exotic charm-zero states is completed with an isospin triplet state at 3.93 GeV and an isospin doublet state at 3.80 GeV. The dominant decay modes involve again the η' meson. The two so far observed s-wave baryons with charm one are recovered. We argue that the $\Lambda_c(2880)$ is not a s-wave state. In addition to those states we predict the existence of about ten narrow s-wave baryon states with masses below 3 GeV. A triplet of crypto-exotic states decaying dominantly into channels with an η' is obtained with masses 4.24 GeV and 4.44 GeV. In the charm-two sector we predict in addition to the chiral excitations of the ground states two triplets of bound states formed by channels involving open-charm mesons. The binding energy of the latter is larger than the one of the chiral excitations.

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1 Introduction

The existence of strongly bound crypto-exotic baryon systems with hidden charm would be a striking feature of strong interactions [1,2,3]. Such states may be narrow since their strong decays are OZI-suppressed [4]. There are experimental hints that such states may indeed be part of nature. A high statistics bubble chamber experiment performed 30 years ago with a K^- beam reported on a possible signal for a hyperon resonance of mass 3.17 GeV of width smaller than 20 MeV [5]. About ten years later a further bubble chamber experiment using a high energy π^- beam suggested a nucleon resonance of mass 3.52 GeV with a narrow width of 7^{+20}_{-7} MeV [6].

It is the purpose of the present work to perform a study addressing the possible existence of crypto-exotic baryon systems. In view of the highly speculative nature of such states it is important to correlate the properties of such states to those firmly established, applying a unified and quantitative framework. Our strategy will be to extend previous works [7,8] that performed a coupled-channel study of the s-wave scattering processes where a Goldstone boson hits an open-charm baryon ground state. The spectrum of $J^P = \frac{1}{2}^-$ and $J^P = \frac{3}{2}^-$ molecules obtained in [7,8] is quite compatible with the so far very few observed states. We mention that analogous computations successfully describe the spectrum of open-charm mesons with $J^P = 0^+$ and 1^+ quantum numbers [9,10]. These developments were driven by the conjecture that meson and baryon resonances that do not belong to the large-N_c ground state of QCD should be viewed as hadronic molecular states [11,12,13,14,15]. Extending those computations to include D- and η_c-mesons in the intermediate states offers the possibility to address the formation of crypto-exotic baryon states (see also [16,17,18,19]). The results of [7,8] were based on the leading order chiral Lagrangian, that predicts unambiguously the s-wave interaction strength of Goldstone bosons with open-charm baryon states in terms of the pion decay constant. Including the light vector mesons as explicit degrees of freedom in a chiral Lagrangian gives an interpretation of the leading order interaction in terms of the zero-range t-channel exchange of light vector mesons [20,21,22,23,24]. The latter couple universally to any matter field in this type of approach. Given the assumption that the interaction strength of D- and η_c-mesons with the baryon ground states is also dominated by the t-channel exchange of the light vector mesons, we are in a position to perform a quantitative coupled-channel study of crypto-exotic baryon resonances.

The work is organized as follows. In section 2 the t-channel force implied by the exchange of vector mesons is constructed defining the leading interaction of the mesons with the baryons. We consider the ground states with $J^P = 0^-, \frac{1}{2}^+$ quantum numbers composed out of u, d, s, c quarks. Constraints imposed by chiral symmetry and large-N_c QCD are discussed. In section 3 we identify

the coupled-channel states considered in our study. Applying the formalism developed in [11,13] the scattering amplitudes are written down explicitly in terms of Clebsch-Gordon coefficients collected in Appendix A. Numerical results are presented in section 4. A brief summary is given in section 5.

The interaction strengths of the channels that drive the resonance generation are predicted by chiral and large-N_c properties of QCD. The spectrum of $J^P = \frac{1}{2}^-$ molecules obtained is amazingly rich of structure. We do recover a nucleon resonance at around 3.3-3.5 GeV as suggested in [6]. It is a coupled-channel bound-state of the $\eta_c\, N$ and $\bar{D}\,\Sigma_c$ states, that decays dominantly into the $\eta' N$ channel. Its decay width is driven by the t-channel exchange of charm. Using a SU(4) estimate a width results of about 150 MeV. Moderate SU(4) breaking allows to reduce the width down to 5-20 MeV within the range suggested in [6]. A small OZI violating $\phi_\mu\, D\bar{D}$ vertex can be used to increase the mass of the state up to the empirical value of 3.52 GeV. Reducing the strength of the η' coupling strength to the open-charm mesons, away from its SU(4) estimate, the crypto-exotic nucleon resonance can be made with narrow width. The state belongs to a SU(3) octet, with all members decaying preferably into channels involving the η' meson. The isospin singlet, doublet and triplet come at (3.58, 3.80, 3.93) GeV respectively. Most striking is an even stronger bound $(\bar{D}_s \Lambda_c), (\bar{D}\,\Xi_c)$ system. Its mass is close to a state possibly observed at 3.17 GeV as reported in [5]. Since it is a SU(3) singlet its decay into channels involving the η' meson is suppressed. As a result a width smaller than 1 MeV is predicted. This is compatible with [5].

Further interesting results are obtained in the charm minus one sector. Exotic states with strangeness minus one and two are predicted at mass 2.78 GeV and 2.84 GeV. In the charm one sector we recover the $\Lambda_c(2593)$ as a narrow state coupling strongly to the $(D\,N)$ and $(D_s\,\Lambda)$ states. The $\Xi_c(2790)$ is interpreted as a bound state of the $(\bar{K}\,\Sigma_c), (\eta\,\Xi_c')$ system. We argue that the $\Lambda_c(2880)$ discovered by the CLEO collaboration can not be a s-wave state. About ten additional narrow s-wave states are predicted in this sector with masses below 3 GeV. For instance, narrow $\Xi_c(2670)$ and $\Xi_c(2760)$ stats are obtained that couple strongly to the $(D\,\Sigma), (D_s\Xi)$ and $(D\,\Lambda), (D_s\Xi)$ states respectively. A narrow $\Lambda_c(2815)$ state is foreseen that is formed by the $(\eta\,\Lambda_c), (K\,\Xi_c)$ system. A narrow $\Sigma_c(2620)$ state couples strongly to the $(D\,N)$ and $(D_s\Sigma)$ states.

2 Coupled-channel interactions

We study the interaction of pseudoscalar mesons with the ground-state baryons composed out of u,d,s,c quarks. The pseudoscalar mesons that are considered in this work can be grouped into multiplet fields $\Phi_{[9]}, \Phi_{[\bar{3}]}$ and $\Phi_{[1]}$. We introduce the fields

$$
\begin{aligned}
\Phi_{[9]} &= \tau \cdot \pi(139) + \alpha^\dagger \cdot K(494) + K^\dagger(494) \cdot \alpha + \eta(547)\, \lambda_8 + \sqrt{\tfrac{2}{3}}\, \mathbf{1}\, \eta'(958)\,, \\
\Phi_{[\bar{3}]} &= \tfrac{1}{\sqrt{2}}\, \alpha^\dagger \cdot D\ \ (1867) - \tfrac{1}{\sqrt{2}}\, D^t\,(1867) \cdot \alpha + i\, \tau_2\, D^{(s)}(1969)\,, \\
\Phi_{[1]} &= \eta_c(2980)\,,
\end{aligned}
\tag{1}
$$

decomposed further into SU(2) multiplets. The approximate masses in units of MeV as used in this work are recalled in brackets [25]. The matrices τ and α are given in terms of the Gell-Mann SU(3) generators $\lambda_{1,\ldots,8}$ with

$$
\tau = (\lambda_1, \lambda_2, \lambda_3), \quad \alpha^\dagger = \frac{1}{\sqrt{2}}(\lambda_4 + i\lambda_5, \lambda_6 + i\lambda_7)\,. \tag{2}
$$

The baryon states are collected into SU(3) multiplet fields $B_{[8]}, B_{[6]}, B_{[3]}$ and $B_{[\bar{3}]}$. Again a further decomposition into isospin multiplets is useful

$$
\begin{aligned}
\sqrt{2}\, B_{[8]} &= \tau \cdot \Sigma(1193) + \alpha^\dagger \cdot N(939) + \Xi^t(1318) \cdot \alpha + \Lambda(1116)\ \lambda_8\,, \\
\sqrt{2}\, B_{[6]} &= \tfrac{1}{\sqrt{2}}\, \alpha^\dagger \cdot \Xi_c(2576) + \tfrac{1}{\sqrt{2}}\, \Xi_c^t(2576) \cdot \alpha + \Sigma_c(2452) \cdot (i\, \tau\, \tau_2) \\
&\quad + \tfrac{\sqrt{2}}{3}\, (1 - \sqrt{3}\, \lambda_8)\, \Omega_c(2698)\,, \\
\sqrt{2}\, B_{[\bar{3}]} &= \tfrac{1}{\sqrt{2}}\, \alpha^\dagger \cdot \Xi_c\,(2469) - \tfrac{1}{\sqrt{2}}\, \Xi_c^t\,(2469) \cdot \alpha + i\, \tau_2\, \Lambda_c(2285)\,, \\
\sqrt{2}\, B_{[3]} &= \tfrac{1}{\sqrt{2}}\, \alpha^\dagger \cdot \Xi_{cc}(3440) - \tfrac{1}{\sqrt{2}}\, \Xi_{cc}^t(3440) \cdot \alpha + i\, \tau_2\, \Omega_{cc}(3560)\,.
\end{aligned}
\tag{3}
$$

The mass of the Ξ_{cc} state is unknown so far. We assume the somewhat ad-hoc value 3.44 GeV [1]. The mass of the Ω_{cc} state is estimated from quark-model calculations [29] which predict a typical splitting to the Ξ_{cc} of about 100-150 MeV. In the SU(3) limit the kinetic terms of the various fields take the form

$$
\begin{aligned}
\mathcal{L}_{\rm kin}^{\rm SU(3)} &= \tfrac{1}{4}\, {\rm tr}\, \Big((\partial_\mu\, \Phi_{[9]})\, (\partial^\mu\, \Phi_{[9]}) - {\rm m}_{[9]}^2\, \Phi_{[9]}\, \Phi_{[9]} \Big) + {\rm tr}\, \bar{\rm B}_{[8]}\, ({\rm i}\, \partial\!\!\!/ - {\rm M}_{[8]})\, {\rm B}_{[8]} \\
&\quad + {\rm tr}\, \bar{\rm B}_{[6]}\, ({\rm i}\, \partial\!\!\!/ - {\rm M}_{[6]})\, {\rm B}_{[6]} + \tfrac{1}{2}\, {\rm tr}\, \Big((\partial_\mu\, \Phi_{[\bar{3}]}^\dagger)\, (\partial^\mu\, \Phi_{[\bar{3}]}) - {\rm m}_{[\bar{3}]}^2\, \Phi_{[\bar{3}]}^\dagger\, \Phi_{[\bar{3}]} \Big) \\
&\quad + {\rm tr}\, \bar{\rm B}_{[\bar{3}]}\, ({\rm i}\, \partial\!\!\!/ - {\rm M}_{[\bar{3}]})\, {\rm B}_{[\bar{3}]} + {\rm tr}\, \bar{\rm B}_{[3]}\, ({\rm i}\, \partial\!\!\!/ - {\rm M}_{[3]})\, {\rm B}_{[3]} \\
&\quad + \tfrac{1}{2}\, \Big((\partial_\mu\, \Phi_{[1]})\, (\partial^\mu\, \Phi_{[1]}) - m_{[1]}^2\, \Phi_{[1]}\, \Phi_{[1]} \Big)\,,
\end{aligned}
\tag{4}
$$

[1] There are hints that the double-charm Ξ_{cc} state at 3519 MeV [26] has not $J^P = \frac{1}{2}^+$ quantum numbers [27,28].

where the mass parameters may be taken as appropriate averages of the values implicit in (1, 3).

In a first step we construct the interaction of the mesons and baryon fields introduced in (1, 3) with the nonet-field of light vector mesons

$$
\begin{aligned}
V_\mu^{[9]} &= \tau \cdot \rho_\mu(770) + \alpha^\dagger \cdot K_\mu(894) + K_\mu^\dagger(894) \cdot \alpha \\
&\quad + \Big(\tfrac{2}{3} + \tfrac{1}{\sqrt{3}}\,\lambda_8\Big)\, \omega_\mu(783) + \Big(\tfrac{\sqrt{2}}{3} - \sqrt{\tfrac{2}{3}}\,\lambda_8\Big)\, \phi_\mu(1020)\,. \qquad (5)
\end{aligned}
$$

We write down a complete list of SU(3) invariant 3-point vertices that involve the minimal number of derivatives. Consider first the terms involving pseudo-scalar fields:

$$
\begin{aligned}
\mathcal{L}_{\rm int}^{\rm SU(3)} &= \tfrac{i}{4}\, h_{\bar 3 \bar 3}^{9}\; {\rm tr}\,\Big((\partial_\mu \Phi_{[\bar 3]})\, \Phi^\dagger_{[\bar 3]} V^\mu_{[9]} - \Phi_{[\bar 3]}\, (\partial_\mu \Phi^\dagger_{[\bar 3]})\, V^\mu_{[9]} \Big) \\
&\quad + \tfrac{i}{4}\, h_{\bar 3 \bar 3}^{1}\; {\rm tr}\,\Big((\partial_\mu \Phi_{[\bar 3]})\, \Phi^\dagger_{[\bar 3]} - \Phi_{[\bar 3]}\, (\partial_\mu \Phi^\dagger_{[\bar 3]}) \Big) \cdot {\rm tr}\,\Big(V^\mu_{[9]} \Big) \\
&\quad + \tfrac{i}{4}\, h_{99}^{9}\; {\rm tr}\,\Big((\partial_\mu \Phi_{[9]})\, \Phi_{[9]}\, V^\mu_{[9]} - \Phi_{[9]}\, (\partial_\mu \Phi_{[9]})\, V^\mu_{[9]} \Big)\,. \qquad (6)
\end{aligned}
$$

It needs to be emphasized that the terms in (6) are not at odds with the constraints set by chiral symmetry provided the light vector mesons are coupled to matter fields via a gauge principle [20,24]. The latter requires a correlation of the coupling constants h in (6)

$$
h_{99}^{9} = \frac{(m_{[9]}^{(V)})^2}{2\, g\, f^2}\,, \qquad h_{\bar 3 \bar 3}^{9} = 2\, g\,, \qquad (7)
$$

with the pion decay constant $f \simeq 92$ MeV. Here the universal vector coupling strength is $g \simeq 6.6$ and the mass of the light vector mesons is $m_{[9]}^{(V)}$.

We continue with the construction of the three-point vertices involving baryon fields. A complete list of SU(3) invariant terms reads:

$$
\begin{aligned}
\mathcal{L}_{\rm int}^{\rm SU(3)} &= \tfrac{1}{2}\, g_{33}^{9}\, {\rm tr}\,\Big(\bar B_{[3]}\, \gamma_\mu\, B_{[3]}\, V^\mu_{[9]} \Big) + \tfrac{1}{2}\, g_{33}^{1}\, {\rm tr}\,\Big(\bar B_{[3]}\, \gamma_\mu\, B_{[3]} \Big)\, {\rm tr}\,\Big(V^\mu_{[9]} \Big) \\
&\quad + \tfrac{1}{2}\, g_{\bar 3 \bar 3}^{9}\, {\rm tr}\,\Big(\bar B_{[\bar 3]}\, \gamma_\mu\, V^\mu_{[9]}\, B_{[\bar 3]} \Big) + \tfrac{1}{2}\, g_{\bar 3 \bar 3}^{1}\, {\rm tr}\,\Big(\bar B_{[\bar 3]}\, \gamma_\mu\, B_{[\bar 3]} \Big)\, {\rm tr}\,\Big(V^\mu_{[9]} \Big) \\
&\quad + \tfrac{1}{2}\, g_{66}^{9}\, {\rm tr}\,\Big(\bar B_{[6]}\, \gamma_\mu\, V^\mu_{[9]}\, B_{[6]} \Big) + \tfrac{1}{2}\, g_{66}^{1}\, {\rm tr}\,\Big(\bar B_{[6]}\, \gamma_\mu\, B_{[6]} \Big)\, {\rm tr}\,\Big(V^\mu_{[9]} \Big) \\
&\quad + \tfrac{1}{2}\, g_{88}^{9-}\, {\rm tr}\,\Big(\bar B_{[8]}\, \gamma_\mu\, \Big[V^\mu_{[9]}\,, B_{[8]} \Big]_- \Big) + \tfrac{1}{2}\, g_{88}^{9+}\, {\rm tr}\,\Big(\bar B_{[8]}\, \gamma_\mu\, \Big[V^\mu_{[9]}\,, B_{[8]} \Big]_+ \Big) \\
&\quad + \tfrac{1}{2}\, g_{88}^{1}\, {\rm tr}\,\Big(\bar B_{[8]}\, \gamma_\mu\, B_{[8]} \Big)\, {\rm tr}\,\Big(V^\mu_{[9]} \Big) \\
&\quad + \tfrac{1}{2}\, g_{\bar 3 6}^{9}\, {\rm tr}\,\Big(\bar B_{[\bar 3]}\, \gamma_\mu\, V^\mu_{[9]}\, B_{[6]} + \bar B_{[6]}\, \gamma_\mu\, V^\mu_{[9]}\, B_{[\bar 3]} \Big)\,. \qquad (8)
\end{aligned}
$$

Within the hidden local symmetry model [24] chiral symmetry is recovered with

$$g^{9}_{\bar{3}\bar{3}} = g^{9}_{66} = -g^{9}_{33} = 2\,g\,, \qquad g^{9,-}_{88} = g\,, \qquad g^{9,+}_{88} = 0\,, \qquad g^{9}_{36} = 0\,. \tag{9}$$

It is acknowledged that chiral symmetry does not constrain the coupling constants in (6, 8) involving the SU(3) singlet part of the fields. The latter can, however, be constrained by a large-N_c operator analysis [38]. At leading order in the $1/N_c$ expansion the OZI rule [39] is predicted. As a consequence the estimates

$$h^{1}_{\bar{3}\bar{3}} = -g\,, \qquad g^{1}_{\bar{3}\bar{3}} = g^{1}_{66} = 0\,, \qquad g^{1}_{88} = g^{1}_{33} = g\,, \tag{10}$$

follow. We emphasize that the combination of chiral and large-N_c constraints (7, 9, 10) determine all coupling constants introduced in (6, 8).

Before constructing the t-channel exchange forces it is rewarding to dwell a bit more on the coupling constants introduced in (1, 3). One may wonder whether the results obtained are compatible with the approximate SU(4) symmetry of QCD that would arise in the limit of a light charm quark mass. As an amusing result of this exercise we will demonstrate that the KSFR relation [30,31,32] can be derived by insisting on SU(4) symmetric coupling constants. The SU(4) symmetric generalization of (1) is readily written down

$$\begin{aligned}
\mathcal{L}^{\rm SU(4)}_{\rm int} &= \tfrac{i}{4}\,g\,{\rm tr}\left(\left[(\partial_\mu\,\Phi_{[16]})\,,\Phi_{[16]}\right]_- V^\mu_{[16]}\right)\,,\\
\Phi_{[16]} &= \begin{pmatrix}
\pi_0+\frac{1}{\sqrt{3}}\,\eta+\sqrt{\frac{2}{3}}\,\eta' & \sqrt{2}\;\pi_+ & \sqrt{2}\;K_+ & \sqrt{2}\;\bar D^0 \\
\sqrt{2}\;\pi_- & -\pi_0+\frac{1}{\sqrt{3}}\,\eta+\sqrt{\frac{2}{3}}\,\eta' & \sqrt{2}\;K^0 & -\sqrt{2}\;\bar D^- \\
\sqrt{2}\;\bar K^- & \sqrt{2}\;\bar K^0 & -\frac{2}{\sqrt{3}}\,\eta+\sqrt{\frac{2}{3}}\,\eta' & \sqrt{2}\;\bar D^-_s \\
\sqrt{2}\;D^0 & -\sqrt{2}\;D^+ & \sqrt{2}\;D^+_s & \sqrt{2}\,\eta_c
\end{pmatrix},\\
V^\mu_{[16]} &= \begin{pmatrix}
\rho^\mu_0+\omega^\mu & \sqrt{2}\;\rho^\mu_+ & \sqrt{2}\;K^\mu_+ & \sqrt{2}\;\bar D^\mu_0 \\
\sqrt{2}\;\rho^\mu_- & -\rho^\mu_0+\omega^\mu & \sqrt{2}\;K^\mu_0 & -\sqrt{2}\;\bar D^\mu_- \\
\sqrt{2}\;\bar K^\mu_- & \sqrt{2}\;\bar K^\mu_{*0} & \sqrt{2}\;\phi^\mu & \sqrt{2}\;\bar D^{s,\mu}_- \\
\sqrt{2}\;D^\mu_0 & -\sqrt{2}\;D^\mu_+ & \sqrt{2}\;D^{s,\mu}_+ & \sqrt{2}\;J/\Psi^\mu
\end{pmatrix}.
\end{aligned} \tag{11}$$

We observe that the interaction (11) is compatible with (7) and (10) if and only if the KSFR relation

$$\frac{(m^{(V)}_{[9]})^2}{2\,f^2\,g} = g\,, \tag{12}$$

holds. This is a surprising result since at first sight the KSFR relation does not seem to be connected with the physics of charm quarks. It is instructive to construct also the SU(4) symmetric generalization of the interaction (8). The baryons form a 20-plet in SU(4). Its field is represented by a tensor B^{ijk}, which is antisymmetric in the first two indices. The indices i, j, k run from one to four, where one can read off the quark content of a baryon state by the identifications $1 \leftrightarrow u, 2 \leftrightarrow d, 3 \leftrightarrow s, 4 \leftrightarrow c$. We write:

$$\mathcal{L}^{\mathrm{SU}(4)}_{\mathrm{int}} = \tfrac{1}{4}\,g \sum_{i,j,k,l=1}^{4} \bar B^{[20]}_{ijk}\,\gamma^\mu \left(V^{[16],k}_{\mu,\,l}\, B^{ijl}_{[20]} + 2\,V^{[16],j}_{\mu,\,l}\, B^{ilk}_{[20]} \right) \tag{13}$$

$$\begin{array}{lll}
B^{121}_{[20]} = p & B^{122}_{[20]} = n & B^{132}_{[20]} = \frac{1}{\sqrt{2}}\Sigma^0 - \frac{1}{\sqrt{6}}\Lambda \\
B^{213}_{[20]} = \frac{2}{\sqrt{6}}\Lambda & B^{231}_{[20]} = \frac{1}{\sqrt{2}}\Sigma^0 + \frac{1}{\sqrt{6}}\Lambda & B^{232}_{[20]} = \Sigma^- \\
B^{233}_{[20]} = \Xi^- & B^{311}_{[20]} = \Sigma^+ & B^{313}_{[20]} = \Xi^0 \\
 & & \\
B^{141}_{[20]} = -\Sigma^{++}_c & B^{142}_{[20]} = \frac{1}{\sqrt{2}}\Sigma^+_c + \frac{1}{\sqrt{6}}\Lambda_c & B^{143}_{[20]} = \frac{1}{\sqrt{2}}\Xi'^+_c - \frac{1}{\sqrt{6}}\Xi^+_c \\
B^{241}_{[20]} = \frac{1}{\sqrt{2}}\Sigma^+_c - \frac{1}{\sqrt{6}}\Lambda_c & B^{242}_{[20]} = \Sigma^0_c & B^{243}_{[20]} = \frac{1}{\sqrt{2}}\Xi'^0_c + \frac{1}{\sqrt{6}}\Xi^0_c \\
B^{341}_{[20]} = \frac{1}{\sqrt{2}}\Xi'^+_c + \frac{1}{\sqrt{6}}\Xi^+_c & B^{342}_{[20]} = \frac{1}{\sqrt{2}}\Xi'^0_c - \frac{1}{\sqrt{6}}\Xi^0_c & B^{343}_{[20]} = \Omega_c \\
 & & \\
B^{124}_{[20]} = \frac{2}{\sqrt{6}}\Lambda^0_c & B^{234}_{[20]} = \frac{2}{\sqrt{6}}\Xi^0_c & B^{314}_{[20]} = \frac{2}{\sqrt{6}}\Xi^+_c \\
 & & \\
B^{144}_{[20]} = \Xi^{++}_{cc} & B^{244}_{[20]} = -\Xi^+_{cc} & B^{344}_{[20]} = \Omega_{cc}\,.
\end{array}$$

It is pointed out that the relations (9, 10) follow from the form of the interaction (13). For completeness we spell out the kinetic term written in terms of the SU(4) multiplet fields:

$$\begin{aligned}
\mathcal{L}^{\mathrm{SU}(4)}_{\mathrm{kin}} &= \tfrac{1}{4} \sum_{i,j=1}^{4} \Big((\partial_\mu\, \Phi^i_{[16],\,j})\,(\partial^\mu\, \Phi^j_{[16],\,i}) - m^2_{[16]}\, \Phi^i_{[16],\,j}\, \Phi^j_{[16],\,i} \Big) \\
&\quad + \tfrac{1}{2} \sum_{i,j,k=1}^{4} \bar B^{[20]}_{ijk} \left(i\,\partial\!\!\!/ - M_{[20]} \right) B^{ijk}_{[20]}\,.
\end{aligned} \tag{14}$$

In contrast to the coupling constants the assumption of a SU(4) symmetry is quite nonsensical for the meson and baryon masses [34]. The notion of $m_{[16]}$ and $M_{[20]}$ in (14) is introduced only to illustrate the normalization of the fields.

We close this section by investigating the coupling of heavy vector mesons,

$V^\mu_{[\bar 3]}$ and $V^\mu_{[1]}$ to the meson and baryon fields. The implications of the vertices (11) and (13) is worked out. The multiplet fields are introduced with

$$
\begin{aligned}
V^{[\bar 3]}_\mu &= \tfrac{1}{\sqrt{2}}\,\alpha^\dagger\cdot D_\mu(2008) - \tfrac{1}{\sqrt{2}}\,D^t_\mu(2008)\cdot\alpha + i\,\tau_2\,D^{(s)}_\mu(2112)\,, \\
V^{[1]}_\mu &= (J/\Psi)_\mu(3097)\,.
\end{aligned}
\tag{15}
$$

We construct first the most general SU(3) symmetric interaction terms involving the pseudoscalar fields:

$$
\begin{aligned}
\mathcal{L}^{\mathrm{SU}(3)}_{\mathrm{int}} &= \tfrac{i}{4}\,h^0_{3\bar 3}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi_{[\bar 3]}\big)\,\Phi^\dagger_{[\bar 3]}V^\mu_{[1]} - \Phi_{[\bar 3]}\,\big(\partial_\mu\Phi^\dagger_{[\bar 3]}\big)\,V^\mu_{[1]}\Big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{9\bar 3}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi^\dagger_{[\bar 3]}\big)\,\Phi_{[9]}\,V^\mu_{[\bar 3]} - \Phi_{[9]}\,\big(\partial_\mu\Phi_{[\bar 3]}\big)\,V^{\dagger\mu}_{[\bar 3]}\Big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{39}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi_{[9]}\big)\,\Phi_{[\bar 3]}V^{\dagger\mu}_{[\bar 3]} - \Phi^\dagger_{[\bar 3]}\,\big(\partial_\mu\Phi_{[9]}\big)\,V^\mu_{[\bar 3]}\Big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{30}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi_{[1]}\big)\,\Phi_{[\bar 3]}V^{\dagger\mu}_{[\bar 3]} - \Phi^\dagger_{[\bar 3]}\,\big(\partial_\mu\Phi_{[1]}\big)\,V^\mu_{[\bar 3]}\Big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{0\bar 3}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi^\dagger_{[\bar 3]}\big)\,\Phi_{[1]}V^\mu_{[\bar 3]} - \Phi_{[1]}\,\big(\partial_\mu\Phi_{[\bar 3]}\big)\,V^{\dagger\mu}_{[\bar 3]}\Big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{31}\;\mathrm{tr}\,\Big(\Phi^\dagger_{[\bar 3]}\,V^\mu_{[\bar 3]} - \Phi_{[\bar 3]}\,V^{\dagger\mu}_{[\bar 3]}\Big)\,\mathrm{tr}\,\big(\partial_\mu\Phi_{[9]}\big) \\
&+ \tfrac{i}{4}\,h^{\bar 3}_{1\bar 3}\;\mathrm{tr}\,\Big(\big(\partial_\mu\Phi_{[\bar 3]}\big)\,V^{\dagger\mu}_{[\bar 3]} - \big(\partial_\mu\Phi^\dagger_{[\bar 3]}\big)\,V^\mu_{[\bar 3]}\Big)\,\mathrm{tr}\,\big(\Phi_{[9]}\big)\,,
\end{aligned}
\tag{16}
$$

where the SU(4) symmetric interaction (11) suggests the identification

$$
\begin{aligned}
&h^0_{3\bar 3} = \sqrt{2}\,g\,, \quad h^{\bar 3}_{9\bar 3} = 2\,g\,, \qquad h^{\bar 3}_{39} = 2\,g\,, \\
&h^{\bar 3}_{30} = \sqrt{2}\,g\,, \quad h^{\bar 3}_{0\bar 3} = \sqrt{2}\,g\,, \quad h^{\bar 3}_{31} = g\,, \quad h^{\bar 3}_{1\bar 3} = g\,.
\end{aligned}
\tag{17}
$$

The prediction of the vertex (11) can be tested against the decay pattern of the D-meson. The parameter combination $h^{\bar 3}_{39} + h^{\bar 3}_{9\bar 3}$ determines the decay process $D_+(2010) \to \pi_+(139)\,D_0(1865)$ as follows

$$
\begin{aligned}
\Gamma_{D_+(2010)\to\pi_+(140)\,D_0(1865)} &= \left(\frac{h^{\bar 3}_{39}+h^{\bar 3}_{9\bar 3}}{4}\right)^2\,\frac{q^3_{\mathrm{cm}}}{8\,\pi\,M^2_{D_+(2010)}} = (64\pm 15)\,\mathrm{keV}\,, \\
q^2_{\mathrm{cm}} &= \left(\frac{M^2_{D_+(2010)} + m^2_{\pi_+(140)} - M^2_{D_0(1865)}}{2\,M_{D_+(2010)}}\right)^2 - m^2_{\pi_+(140)}\,.
\end{aligned}
\tag{18}
$$

From the empirical branching ratio [25] as recalled in (18) we deduce $(h^{\bar 3}_{39} + h^{\bar 3}_{9\bar 3})/4 = 10.4\pm 1.4$, which is confronted with the SU(4) estimate $(h^{\bar 3}_{39}+h^{\bar 3}_{9\bar 3})/4 = g \simeq 6.6$. We observe a small SU(4) breaking pattern. Based on this result one may expect the relations (17) to provide magnitudes for the coupling constants reliable within a factor two.

We close this section with the construction of the most general SU(3) symmetric interaction involving baryon fields

$$
\begin{aligned}
\mathcal{L}_{\rm int}^{\rm SU(3)} &= \tfrac{1}{2}\, g^{0}_{88}\, {\rm tr}\,\Big(\bar B_{[8]}\,\gamma_\mu\, B_{[8]}\, V^\mu_{[1]}\Big) + \tfrac{1}{2}\, g^{0}_{66}\, {\rm tr}\,\Big(\bar B_{[6]}\,\gamma_\mu\, B_{[6]}\, V^\mu_{[1]}\Big) \\
&+ \tfrac{1}{2}\, g^{0}_{\bar 3\bar 3}\, {\rm tr}\,\Big(\bar B_{[\bar 3]}\,\gamma_\mu\, B_{[\bar 3]}\, V^\mu_{[1]}\Big) + \tfrac{1}{2}\, g^{0}_{33}\, {\rm tr}\,\Big(\bar B_{[3]}\,\gamma_\mu\, B_{[3]}\, V^\mu_{[1]}\Big) \\
&+ \tfrac{1}{2}\, g^{\bar 3}_{86}\, {\rm tr}\,\Big(\bar B_{[8]}\,\gamma_\mu\, B_{[6]}\, V^{\dagger\mu}_{[\bar 3]} + \bar B_{[6]}\,\gamma_\mu\, B_{[8]}\, V^{\mu}_{[\bar 3]}\Big) \\
&+ \tfrac{1}{2}\, g^{\bar 3}_{8\bar 3}\, {\rm tr}\,\Big(\bar B_{[8]}\,\gamma_\mu\, B_{[\bar 3]}\, V^{\dagger\mu}_{[\bar 3]} + \bar B_{[\bar 3]}\,\gamma_\mu\, B_{[8]}\, V^{\mu}_{[\bar 3]}\Big) \\
&+ \tfrac{1}{2}\, g^{\bar 3}_{63}\, {\rm tr}\,\Big(\bar B_{[6]}\,\gamma_\mu\, {\rm tr}(B_{[3]}\, V^{\dagger\mu}_{[\bar 3]}) - 2\,\bar B_{[6]}\,\gamma_\mu\, B_{[3]}\, V^{\dagger\mu}_{[\bar 3]} \\
&\qquad\qquad + \bar B_{[3]}\,\gamma_\mu\, V_{[\bar 3]}^{\;\;\mu}\, {\rm tr}\,(B_{[6]}) - 2\,\bar B_{[3]}\,\gamma_\mu\, B_{[6]}\, V_{[\bar 3]}^{\;\;\mu}\Big) \\
&+ \tfrac{1}{2}\, g^{\bar 3}_{\bar 3 3}\, {\rm tr}\,\Big(\bar B_{[\bar 3]}\,\gamma_\mu\, B_{[3]}\, V^{\dagger\mu}_{[\bar 3]} + \bar B_{[3]}\,\gamma_\mu\, B_{[\bar 3]}\, V_{[\bar 3]}^{\;\;\mu}\Big)\,,
\end{aligned}
\qquad (19)
$$

where the SU(4) symmetric vertex (13) implies

$$
\begin{aligned}
&g^{0}_{88} = 0\,, \qquad g^{0}_{66} = \sqrt{2}\, g\,, \qquad g^{0}_{\bar 3\bar 3} = \sqrt{2}\, g\,, \qquad g^{0}_{33} = 2\,\sqrt{2}\, g\,, \\
&g^{\bar 3}_{86} = \sqrt{2}\, g\,, \qquad g^{\bar 3}_{8\bar 3} = -\sqrt{6}\, g\,, \qquad g^{\bar 3}_{63} = g\,, \qquad g^{\bar 3}_{\bar 3 3} = 2\,\sqrt{3}\, g\,.
\end{aligned}
\qquad (20)
$$

Unfortunately there appears to be no way at present to check on the usefulness of the result (20). Eventually simulations of QCD on a lattice may shed some light on this issue. The precise values of the coupling constants (17, 20) will not affect the major results of this work. This holds as long as those coupling constants range in the region suggested by (17, 20) within a factor two.

3 Coupled-channel scattering

We consider the s-wave scattering of the pseudo-scalar mesons fields (1) off the baryon fields (3). The scattering kernel is approximated by the t-channel vector meson exchange force defined by (6, 8), where we apply the formalism developed in [11,13]. The scattering kernel has the form

$$
K^{(I,S,C)}(\bar q, q; w) = -\frac{1}{4} \sum_{V \in [16]} \frac{C_V^{(I,S,C)}}{t - m_V^2} \Big(\frac{\bar{\not q} + \not q}{2} - (\bar q^2 - q^2)\,\frac{\bar{\not q} - \not q}{2\, m_V^2}\Big)\,, \qquad (21)
$$

with the initial and final meson 4-momenta q_μ and $\bar q_\mu$ and $t = (\bar q - q)^2$. It should be mentioned that (21) is valid only under the assumptions $h^{\bar 3}_{39} = h^{\bar 3}_{9\bar 3}$, $h^{\bar 3}_{31} = h^{\bar 3}_{1\bar 3}$ and $h^{\bar 3}_{30} = h^{\bar 3}_{0\bar 3}$. In (21) the scattering is projected onto sectors with conserved isospin (I), strangeness (S) and charm (C) quantum numbers. The latter are introduced with respect to the states collected in Tabs. 1-3, where

we use the notation and conventions of [11,12]. The coupled-channel structure of the matrices $C^{(I,S,C)}_{V,ab}$ is given in the Appendix. Only non-vanishing elements are displayed. Owing to the 'chiral' identifications (7, 9) and the KSFR relation (12) we reproduce the coupled-channel structure of the Weinberg-Tomozawa interaction identically. Summing over the light vector meson states

$$\sum_{V\in[9]} C^{(I,S,C)}_{V} = 4\,g^2\,C^{(I,S,C)}_{WT}\,, \tag{22}$$

we reproduce the matrices C_{WT} as given previously in [11,7]. The first term of the interaction kernel matches corresponding expressions predicted by the leading order chiral Lagrangian if we put $t=0$ in (21) and use the common value for the vector-meson masses suggested by the KSFR relation (12). The second term in (21) is formally of chiral order Q^3 for channels involving Goldstone bosons. Numerically it is a minor correction but nevertheless it is kept in the computation.

Given (17, 20) one may decompose the interaction into SU(4) invariant tensors:

$$\frac{1}{4\,g^2}\sum_{V\in[16]} C^{(I,S,C)}_{V} = 7\,C_{[\overline{4}]} + 4\,C_{[20_1]} + 4\,C_{[20_2]} + C_{[20_s]} + 2\,C_{[\overline{36}]} - 2\,C_{[140]}\,,$$
$$15\otimes 20 = \overline{4}\oplus 20_1\oplus 20_2\oplus 20_s\oplus \overline{36}\oplus\overline{60}\oplus 140\,. \tag{23}$$

The normalization of the matrices $C_{[...]}$ is such that their weight factors in (23) give the eigenvalues of the coupling matrix C. Strongest attraction is foreseen in the $\bar{4}$-plet, repulsion in the 140-plet and no interaction in the 60-plet. Three distinct 20-plet are formed, all receiving identical attractive weight factors. It is interesting to observe that (23) predicts attraction in the $\overline{36}$-plet. This is an exotic multiplet. In order to help the reader to digest this abstract group theory we further decompose the SU(4) multiplets into the more familiar SU(3) multiplets

$$\begin{aligned}
[\overline{4}]^{\rm SU(4)} &= \; [1]^{\rm SU(3)}_{C=0}\oplus[\overline{3}]^{\rm SU(3)}_{C=1}\,,\\
[20]^{\rm SU(4)}_{1,2} &= \; [8]^{\rm SU(3)}_{C=0}\oplus[6]^{\rm SU(3)}_{C=1}\oplus[\overline{3}]^{\rm SU(3)}_{C=1}\oplus[3]^{\rm SU(3)}_{C=2}\,,\\
[20]^{\rm SU(4)}_{s} &= [10]^{\rm SU(3)}_{C=0}\oplus[6]^{\rm SU(3)}_{C=1}\oplus[3]^{\rm SU(3)}_{C=2}\oplus[1]^{\rm SU(3)}_{C=3}\,,\\
[\overline{36}]^{\rm SU(4)} &= \; [3]^{\rm SU(3)}_{C=-1}\oplus[8]^{\rm SU(3)}_{C=0}\oplus[\overline{15}]^{\rm SU(3)}_{C=1}\oplus[\overline{3}]^{\rm SU(3)}_{C=1}\oplus[\overline{6}]^{\rm SU(3)}_{C=2}\,.
\end{aligned} \tag{24}$$

From (23, 24) one may expect the formation of penta-quark type states with negative charm. The persistence of attraction in the exotic $\overline{15}$-plet sector was claimed before in [7]. It should be stressed that the decomposition (23) is more of academic interest, even though it is useful to perform some consistency checks. One carefully has to explore whether the attraction is provided by the

t-channel exchange of the light or heavy vector mesons. This important piece of information is lost in (23).

In this work we neglect the t-dependence of the interaction kernel insisting on $t = 0$ in (21). Following [11,13] the s-wave projected effective scattering kernel, $V^{(I,S,C)}(\sqrt{s}\,)$, is readily constructed:

$$V^{(I,S,C)}(\sqrt{s}\,) = \sum_{V\in[16]} \frac{C_V^{(I,S,C)}}{8\,m_V^2}\left(2\,\sqrt{s} - M - \bar{M} + (\bar{M}-M)\,\frac{\bar{m}^2 - m^2}{m_V^2}\right), \tag{25}$$

where M, $\bar{M}$ and $m, \bar{m}$ are the masses of initial and final baryon and meson states. The scattering amplitudes, $M^{(I,S,C)}(\sqrt{s}\,)$, take the simple form

$$M^{(I,S,C)}(\sqrt{s}\,) = \Big[1 - V^{(I,S,C)}(\sqrt{s}\,)\,J^{(I,S,C)}(\sqrt{s}\,)\Big]^{-1}\,V^{(I,S,C)}(\sqrt{s}\,)\,. \tag{26}$$

The unitarity loop function, $J^{(I,S,C)}(\sqrt{s}\,)$, is a diagonal matrix. Each element depends on the masses of intermediate meson and baryon, m and M, respectively:

$$\begin{aligned}
J(\sqrt{s}\,) &= \Big(M + (M^2 + p_{\rm cm}^2)^{1/2}\Big)\,\Big(I(\sqrt{s}\,) - I(\mu)\Big)\,,\\
I(\sqrt{s}\,) &= \frac{1}{16\,\pi^2}\left(\frac{p_{\rm cm}}{\sqrt{s}}\left(\ln\left(1 - \frac{s - 2\,p_{\rm cm}\sqrt{s}}{m^2 + M^2}\right) - \ln\left(1 - \frac{s + 2\,p_{\rm cm}\sqrt{s}}{m^2 + M^2}\right)\right)\right.\\
&\quad \left. + \left(\frac{1}{2}\,\frac{m^2 + M^2}{m^2 - M^2} - \frac{m^2 - M^2}{2\,s}\right)\,\ln\left(\frac{m^2}{M^2}\right) + 1\right) + I(0)\,,
\end{aligned} \tag{27}$$

where $\sqrt{s} = \sqrt{M^2 + p_{\rm cm}^2} + \sqrt{m^2 + p_{\rm cm}^2}$. A crucial ingredient of the approach developed in [11,13] is its approximate crossing symmetry guaranteed by a proper choice of the subtraction scales μ. The latter depends on the quantum number (I, S, C) but should be chosen uniformly within a given sector [11,13,14,15]. We insist on

$$\mu = \sqrt{m_{\rm th}^2 + M_{\rm th}^2}\,, \qquad m_{\rm th} + M_{\rm th} = {\rm Min}\{m_a + M_a\}\,. \tag{28}$$

As a consequence of (28) the s-channel and u-channel unitarized amplitudes involving the lightest channels can be matched smoothly at the subtraction point μ [11,13,14,15]. The construction (28) implies that the effect of heavy channels, like the $\eta_c\,N$ channel, on the light channels, like the $\pi\,N$ channel, is naturally suppressed. Since the $\eta_c\,N$ loop function is extremely smooth for $\sqrt{s} \ll m_{\eta_c} + M_N$, enforcing the loop to vanish at $s = \mu^2 = m_\pi^2 + m_N^2$ ensures that the heavy channel has a negligible effect on the low-energy scattering of

the light channel. Such a mechanism is required as to prevent an uncontrolled renormalization of the Weinberg-Tomozawa interaction strength. If the $\eta_c\, N$ loop would have a significant size at $s = m_N^2 + m_\pi^2$, integrating out the η_c-field would predict an effective scattering kernel for the $\pi\, N \to \pi\, N$ system that is in conflict with chiral symmetry.

$(0,0,-1)$	$(1,0,-1)$	$(\frac{1}{2},-1,-1)$	$(\frac{3}{2},-1,-1)$
$(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2 N)$	$(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\vec{\sigma}\, N)$	$(\bar{D}_s\, N)$ $(\Lambda\, \bar{D})$ $(\frac{1}{\sqrt{3}}\Sigma\cdot\sigma\bar{D})$	$(\Sigma\cdot T\,\bar{D})$

$(0,-2,-1)$	$(1,-2,-1)$	$(\frac{1}{2},-3,-1)$
$(\bar{D}_s\,\Lambda)$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\,\Xi)$	$(\bar{D}_s\,\vec{\Sigma})$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\vec{\sigma}\,\Xi)$	$(\bar{D}_s\,\Xi)$

$(0,1,0)$	$(1,1,0)$	$(\frac{1}{2},0,0)$	$(\frac{3}{2},0,0)$
$(\frac{1}{\sqrt{2}}K^t\, i\sigma_2\, N)$	$(\frac{1}{\sqrt{2}}K^t\, i\sigma_2\vec{\sigma}\, N)$	$(\frac{1}{\sqrt{3}}\pi\cdot\sigma\, N)$ $(\eta\, N)$ $(\Lambda\, K)$ $(\frac{1}{\sqrt{3}}\Sigma\cdot\sigma\, K)$ $(\eta'\, N)$ $(\eta_c\, N)$ $(\Lambda_c\,\bar{D})$ $(\frac{1}{\sqrt{3}}\Sigma_c\cdot\sigma\,\bar{D})$	$(\pi\cdot T\, N)$ $(\Sigma\cdot T\, K)$ $(\Sigma_c\cdot T\,\bar{D})$

$(0,-1,0)$	$(1,-1,0)$	$(2,-1,0)$	$(\frac{1}{2},-2,0)$
$(\frac{1}{\sqrt{3}}\Sigma\cdot\pi)$ $(\frac{1}{\sqrt{2}}\bar{K}N)$ $(\Lambda\,\eta)$ $(\frac{1}{\sqrt{2}}K^t\, i\sigma_2\,\Xi)$ $(\Lambda\,\eta')$ $(\Lambda\,\eta_c)$ $(\Lambda_c\,\bar{D}_s)$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\,\Xi_c)$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\,\Xi'_c)$	$(\Lambda\,\vec{\pi})$ $(\frac{i}{\sqrt{2}}\vec{\Sigma}\times\vec{\pi})$ $(\frac{1}{\sqrt{2}}\bar{K}\vec{\sigma}\, N)$ $(\eta\,\vec{\Sigma})$ $(\frac{1}{\sqrt{2}}K^t\, i\sigma_2\vec{\sigma}\,\Xi)$ $(\eta'\vec{\Sigma})$ $(\eta_c\vec{\Sigma})$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\vec{\sigma}\,\Xi_c)$ $(\bar{D}_s\vec{\Sigma}_c)$ $(\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\vec{\sigma}\,\Xi'_c)$	$(\Sigma\cdot S\cdot\pi)$	$(\frac{1}{\sqrt{3}}\pi\cdot\sigma\,\Xi)$ $(\Lambda\, i\sigma_2\,\bar{K}^t)$ $(\frac{1}{\sqrt{3}}\Sigma\,\cdot\sigma i\sigma_2\,\bar{K}^t)$ $(\eta\,\Xi)$ $(\eta'\,\Xi)$ $(\eta_c\,\Xi)$ $(\bar{D}_s\,\Xi_c)$ $(\bar{D}_s\,\Xi'_c)$ $(\Omega_c\,\bar{D})$

$(\frac{3}{2},-2,0)$	$(0,-3,0)$	$(1,-3,0)$
$(\pi\cdot T\,\Xi)$ $(\Sigma\cdot T\, i\sigma_2\,\bar{K}^t)$	$(\frac{1}{\sqrt{2}}\bar{K}\,\Xi)$ $(\bar{D}_s\,\Omega_c)$	$(\frac{1}{\sqrt{2}}\bar{K}\,\vec{\sigma}\,\Xi)$

Table 1
Definition of coupled-channel states with isospin (I), strangeness (S) and charm (C). Here $C=-1,0$.

$(\frac{1}{2},1,1)$	$(\frac{3}{2},1,1)$	$(0,0,1)$	$(1,0,1)$
$\begin{pmatrix} (\Lambda_c\, K) \\ (D_s\, N) \\ (\frac{1}{\sqrt{3}}\Sigma_c \cdot \sigma\, K) \end{pmatrix}$	$(\Sigma_c \cdot T\, K)$	$\begin{pmatrix} (\frac{1}{\sqrt{3}}\pi \cdot \Sigma_c) \\ (\frac{1}{\sqrt{2}}D\, N) \\ (\Lambda_c\, \eta) \\ (\frac{1}{\sqrt{2}}K^t\, i\sigma_2\, \Xi_c) \\ (\frac{1}{\sqrt{2}}K^t\, i\sigma_2\, \Xi_c') \\ (D_s\, \Lambda) \\ (\Lambda_c\, \eta') \\ (\Lambda_c\, \eta_c) \\ (\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\, \Xi_{cc}) \end{pmatrix}$	$\begin{pmatrix} (\Lambda_c\, \vec{\pi}) \\ (\frac{i}{\sqrt{2}}\vec{\Sigma}_c \times \vec{\pi}) \\ (\frac{1}{\sqrt{2}}D\, \vec{\sigma}\, N) \\ (\frac{1}{\sqrt{2}}K^t\, i\sigma_2\vec{\sigma}\, \Xi_c) \\ (\eta\, \vec{\Sigma}_c) \\ (\frac{1}{\sqrt{2}}K^t\, i\sigma_2\vec{\sigma}\, \Xi_c') \\ (D_s\, \vec{\Sigma}) \\ (\eta'\, \vec{\Sigma}_c) \\ (\frac{1}{\sqrt{2}}\bar{D}^t\, i\sigma_2\vec{\sigma}\, \Xi_{cc}) \\ (\eta_c\, \vec{\Sigma}_c) \end{pmatrix}$

$(2,0,1)$	$(\frac{1}{2},-1,1)$	$(\frac{3}{2},-1,1)$	$(0,-2,1)$
$(\Sigma_c \cdot S \cdot \pi)$	$\begin{pmatrix} (\frac{1}{\sqrt{3}}\pi \cdot \sigma\, \Xi_c) \\ (\frac{1}{\sqrt{3}}\pi \cdot \sigma\, \Xi_c') \\ (\Lambda_c\, i\sigma_2\, \bar{K}^t) \\ (\frac{1}{\sqrt{3}}\Sigma_c \cdot \sigma i\sigma_2\, \bar{K}^t) \\ (\Lambda\, i\sigma_2\, D^t) \\ (\eta\, \Xi_c) \\ (\frac{1}{\sqrt{3}}\Sigma \cdot \sigma i\sigma_2\, D^t) \\ (\eta\, \Xi_c') \\ (\Omega_c\, K) \\ (D_s\, \Xi) \\ (\eta'\, \Xi_c) \\ (\eta'\, \Xi_c') \\ (\eta_c\, \Xi_c) \\ (\bar{D}_s\, \Xi_{cc}) \\ (\Omega_{cc}\, \bar{D}) \\ (\eta_c\, \Xi_c') \end{pmatrix}$	$\begin{pmatrix} (\pi \cdot T\, \Xi_c) \\ (\pi \cdot T\, \Xi_c') \\ (\Sigma_c \cdot T\, i\sigma_2\, \bar{K}^t) \\ (\Sigma \cdot T i\sigma_2 D^t) \end{pmatrix}$	$\begin{pmatrix} (\frac{1}{\sqrt{2}}\bar{K}\, \Xi_c) \\ (\frac{1}{\sqrt{2}}\bar{K}\, \Xi_c') \\ (\frac{1}{\sqrt{2}}D\, \Xi) \\ (\Omega_c\, \eta) \\ (\Omega_c\, \eta') \\ (\Omega_{cc}\, \bar{D}_s) \\ (\Omega_c\, \eta_c) \end{pmatrix}$

$(1,-2,1)$	$(\frac{1}{2},-3,1)$
$\begin{pmatrix} (\Omega_c\, \vec{\pi}) \\ (\frac{1}{\sqrt{2}}\bar{K}\, \vec{\sigma}\, \Xi_c) \\ (\frac{1}{\sqrt{2}}\bar{K}\, \vec{\sigma}\, \Xi_c') \\ (\frac{1}{\sqrt{2}}D\, \vec{\sigma}\, \Xi) \end{pmatrix}$	$(\Omega_c\, i\sigma_2\, \bar{K}^t)$

Table 2
Definition of coupled-channel states with $C = 1$.

$(0,1,2)$	$(1,1,2)$	$(\frac{1}{2},0,2)$	$(\frac{3}{2},0,2)$
$\begin{pmatrix} (\frac{1}{\sqrt{2}} K^t\, i\sigma_2\, \Xi_{cc}) \\ (\Lambda_c\, D_s) \end{pmatrix}$	$\begin{pmatrix} (\frac{1}{\sqrt{2}} K^t\, i\sigma_2 \vec{\sigma}\, \Xi_{cc}) \\ (D_s\, \vec{\Sigma}_c) \end{pmatrix}$	$\begin{pmatrix} (\frac{1}{\sqrt{3}} \pi \cdot \sigma \Xi_{cc}) \\ (\eta\, \Xi_{cc}) \\ (\Omega_{cc}\, K) \\ (\Lambda_c\, i\sigma_2\, D^t) \\ (\frac{1}{\sqrt{3}} \Sigma_c \cdot \sigma i\sigma_2\, D^t) \\ (\eta'\, \Xi_{cc}) \\ (D_s\, \Xi_c) \\ (D_s\, \Xi'_c) \\ (\eta_c\, \Xi_{cc}) \end{pmatrix}$	$\begin{pmatrix} (\pi \cdot T\, \Xi_{cc}) \\ (\Sigma_c \cdot T\, i\sigma_2\, D^t) \end{pmatrix}$

$(0,-1,2)$	$(1,-1,2)$	$(\frac{1}{2},-2,2)$
$\begin{pmatrix} (\frac{1}{\sqrt{2}} \bar{K}\, \Xi_{cc}) \\ (\Omega_{cc}\, \eta) \\ (\frac{1}{\sqrt{2}} D\, \Xi_c) \\ (\frac{1}{\sqrt{2}} D\, \Xi'_c) \\ (\Omega_{cc}\, \eta') \\ (D_s\, \Omega_c) \\ (\Omega_{cc}\, \eta_c) \end{pmatrix}$	$\begin{pmatrix} (\Omega_{cc}\, \vec{\pi}) \\ (\frac{1}{\sqrt{2}} \bar{K}\, \vec{\sigma}\, \Xi_{cc}) \\ (\frac{1}{\sqrt{2}} D\, \vec{\sigma}\, \Xi_c) \\ (\frac{1}{\sqrt{2}} D\, \vec{\sigma}\, \Xi'_c) \end{pmatrix}$	$\begin{pmatrix} (\Omega_{cc}\, i\sigma_2\, \bar{K}^t) \\ (\Omega_c\, i\sigma_2\, D^t) \end{pmatrix}$

$(\frac{1}{2},1,3)$	$(0,0,3)$	$(1,0,3)$	$(\frac{1}{2},-1,3)$
$(D_s\, \Xi_{cc})$	$\begin{pmatrix} (\frac{1}{\sqrt{2}} D\, \Xi_{cc}) \\ (\Omega_{cc}\, D_s) \end{pmatrix}$	$(\frac{1}{\sqrt{2}} D\, \vec{\sigma}\, \Xi_{cc})$	$(\Omega_{cc}\, i\sigma_2\, D^t)$

Table 3
Definition of coupled-channel states with $C = 2, 3$.

4 Numerical results

In order to study the formation of baryon resonances we produce generalized speed plots [33,13] of the simple form

$$\text{Speed}_{ab}(\sqrt{s}\,) = \Big|\frac{d}{d\sqrt{s}}\,[\,M_{ab}(\sqrt{s}\,)]\Big|\,. \tag{29}$$

If a partial-wave scattering amplitude develops a resonance or bound state, close to that structure it may be approximated by a pole and a background term. We write

$$M_{ab}(\sqrt{s}\,) \simeq -\frac{g_a^*\,g_b}{\sqrt{s}-M_R+i\,\Gamma_R/2} + b_{ab}\,, \tag{30}$$

with the resonance mass M_R and width Γ_R. The dimension less coupling constants g_b and g_a parameterize the coupling strength of the resonance to the initial and final channels. The background term b_{ab} is in general a complex number. If the scattering amplitude has the form (30) its speed takes a maximum at the resonance mass M_R. The ratio of coupling constants to total decay width Γ_R is then determined by the value the speed takes at its maximum

$$\text{Speed}_{aa}(M_R) = \left|\frac{2\,g_a}{\Gamma_R}\right|^2. \tag{31}$$

We determine the resonance position and coupling constants by adjusting the parameters M_R and g_a to the Speed of its associated amplitudes. This is an approximate procedure, fully sufficient in view of the schematic nature of the computation. We will present the Speed functions on a logarithmic scale. This presentation has the advantage that a resonance signal can be cleanly separated from a cusp effect. Whereas a cusp effect leads to a structure confined in small interval around the threshold that defines the cusp, a resonance defines a much more extended arête-like form.

If a resonance is produced in a two-body collision the formation cross section can be expressed in terms of the coupling constants as follows

$$\sum_b \sigma^{\rm form}_{a\to b} = \frac{\sqrt{M_a^2+q_{\rm cm}^2}+M_a}{q_{\rm cm}\,\Gamma_R\,M_R}\,g_a^2\,, \quad M_R = \sqrt{M_a^2+q_{\rm cm}^2}+\sqrt{m_a^2+q_{\rm cm}^2}\,, \tag{32}$$

where it is assumed that the initial state has a well defined isospin. An appropriate Clebsch-Gordon coefficient has to be supplied that projects the initial state onto the isospin quantum numbers of the resonance considered.

$C=-1:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\vert g_R\vert$	M_R[MeV] Γ_R [MeV]	$\vert g_R\vert$
$(\frac{1}{2},-1)$	$\bar D_s N$	2687	3.8	2780	3.3
	$\bar D\,\Lambda$	0	1.4	0	1.1
	$\bar D\,\Sigma$		5.4		4.9
$(0,-2)$	$\bar D_s\Lambda$	2763	3.4	2838	3.0
	$\bar D\,\Xi$	0	6.1	0	5.6

Table 4
Spectrum of $J^P=\frac{1}{2}^-$ baryons with charm minus one. The 3rd and 4th columns follow with the universal vector coupling constant $g=6.6$ and SU(4) symmetric 3-point vertices. In the 5th and 6th columns we use the SU(4) breaking relation $h^1_{\bar{3}\bar{3}} \simeq -1.19\,g$, which implies a non-vanishing OZI violating $\phi_\mu \bar D D$ vertex. The remaining SU(4) relations (17, 20) are untouched.

4.1 S-wave resonances with charm minus one

We begin with a presentation of results obtained for $J^P=\frac{1}{2}^-$ resonances with negative charm. The possible existence of such states was discussed by Lipkin twenty years ago [40]. Such states were studied in a quark model [41], however, predicting that they are unbound. Recently the H1 collaboration reported on a possible signal for a state with negative charm and zero strangeness at 3.099 GeV [42]. This triggered various theoretical investigations [43,44,45,46,47]. According to a QCD sum rule study [44] the H1 signal should be associated with a p-wave resonance. Since we consider only s-wave resonances in this work, we do not necessarily expect a signal in this sector. Confirming the anticipation of Lipkin [40] we observe bound states with $(I,S)=(\frac{1}{2},-1)$ and $(0,-2)$ only. No bound or resonance-state signal are seen in the remaining sectors.

The properties of the states are collected in Tab. 4. The masses and coupling constants are shown for two cases. First the spectrum is computed insisting on the chiral relations (7, 9) together with the leading order large-N_c relations (10). Relying on the KSFR relation (12, 7) the binding energies are determined by the universal vector coupling constant for which we take the value $g=6.6$ in this work. The masses of the $(\frac{1}{2},-1)$ and $(0,-2)$ states are predicted at 2.69 GeV and 2.76 GeV respectively. We point out that none of the coupling constants fixed in (17, 20) by a SU(4) constraint affect the spectrum. As a consequence of the OZI rule only the t-channel exchange of the light-vector mesons contribute. In the last two columns of Tab. 4 the spectrum is presented if we admit a small OZI violation in the coupling of the light-vector mesons to the D-mesons. A finite coupling strength of the ϕ-meson to the D-mesons is permitted:

$$\begin{aligned}\mathcal{L}^{\rm SU(3)}_{\rm int} &= \tfrac{i}{2}\,(g_{\phi_\mu D\bar D}\,\phi^\mu + g_{\omega_\mu D\bar D}\,\omega^\mu)\,[(\partial_\mu \bar D)\,D - \bar D\,(\partial_\mu D)]\\ &+ \tfrac{i}{2}\,g_{\rho_\mu D\bar D}\,\rho^\mu\,[(\partial_\mu \bar D)\,\vec\sigma\,D - \bar D\,\vec\sigma\,(\partial_\mu D)]\,,\end{aligned}$$

$$
\begin{aligned}
&g_{\phi_\mu D\bar D} = \sqrt{2}\,(h^1_{\bar 3 3} + \tfrac{1}{2}\,h^9_{\bar 3 3})\,, \qquad g_{\omega_\mu D\bar D} = 2\,h^1_{\bar 3 3} + \tfrac{1}{2}\,h^9_{\bar 3 3}\,,\\
&g_{\rho_\mu D\bar D} = \tfrac{1}{2}\,h^9_{\bar 3 3}\,. \qquad (33)
\end{aligned}
$$

We introduce a small OZI violation by increasing the magnitude of $h^1_{\bar 3 3}$ by about 19 % away from its SU(4) value. This keeps the value $g_{\rho_\mu D\bar D} = g = 6.6$ but dials $g_{\phi_\mu D\bar D} \neq 0$. With $g_{\phi_\mu D\bar D} \simeq -1.74$ the binding energy of the two bound states is reduced by 93 MeV and 65 MeV as shown in Tab. 4.

4.2 S-wave resonances with zero charm

We turn to the resonances with $C = 0$. The spectrum as shown in Fig. 1 in terms of the speed introduced in (31), falls into two types of states. Resonances with masses above 3 GeV couple strongly to mesons with non-zero charm content. In the SU(3) limit those states form an octet and a singlet. All other states have masses below 2 GeV. In the SU(3) limit they group into two degenerate octets and one singlet. The presence of the heavy channels does not affect that part of the spectrum at all. This is reflected in coupling constants of those states to the heavy channels within the typical range of $g \sim 0.1$ (see Tabs. 5-6). We reproduce the success of previous coupled-channel computations [14,15], which predicts the existence of the s-wave resonances $N(1535), \Lambda(1405), \Lambda(1670), \Xi(1690)$ unambiguously with masses and branching ratios quite compatible with empirical information. There are some quantitative differences. This is the consequence of the t-channel vector meson exchange, which, only in the SU(3) limit with degenerate vector meson masses, is equivalent to the Weinberg-Tomozawa interaction the computation in [14,15] was based on.

Most spectacular are the resonances with hidden charm above 3 GeV. The multiplet structure of such states is readily understood. The mesons with $C = -1$ form a triplet which is scattered off the $C = +1$ baryons forming a anti-triplet or sextet. We decompose the products into irreducible tensors

$$
3 \otimes \overline{3} = 1 \oplus 8\,, \qquad 3 \otimes 6 = 8 \oplus 10\,. \qquad (34)
$$

The matrix $\sum_{V\in[9]} C_V$ of (21) is attractive in the singlet for the triplet of baryons. Attraction in the octet sector is provided by the sextet of baryons. The resulting octet of states mixes with the $\eta'\,(N, \Lambda, \Sigma, \Xi)$ and $\eta_c\,(N, \Lambda, \Sigma, \Xi)$ systems. A complicated mixing pattern arises. All together the binding energies of the crypto-exotic states are large. This is in part due to the large masses of the coupled-channel states: the kinetic energy the attractive t-channel force has to overcome is reduced. A second kinematical effect, which further increases the binding energy, is implied by the specific form of the t-channel

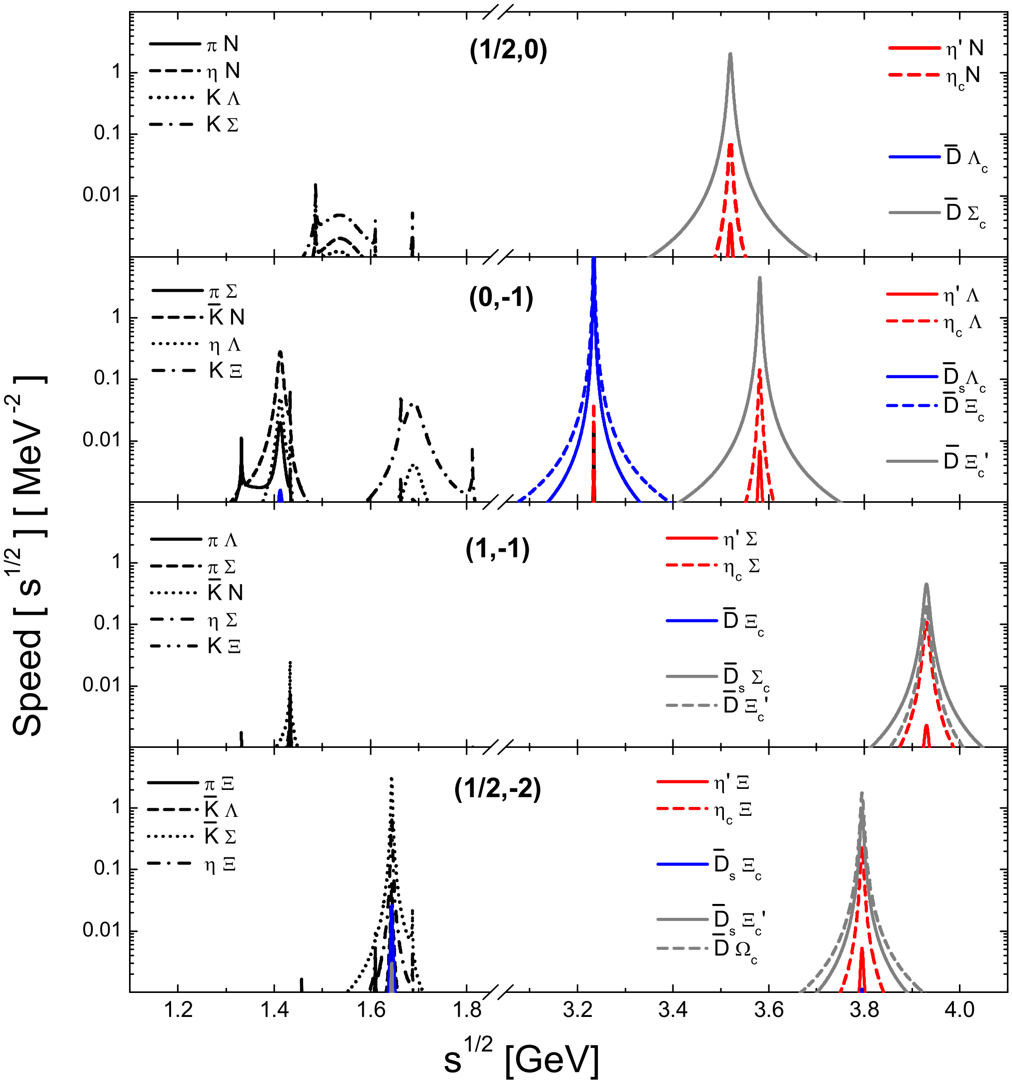

Fig. 1. It is shown the logarithm of the diagonal $\mathrm{Speed}_{aa}(\sqrt{s}\,)$ for all channels where resonances form with $C = 0$.

exchange (25). It provides the factor $2\sqrt{s} - M - \bar{M}$. If evaluated at threshold it scales with the meson mass.

The states shown in Fig. 1 are narrow as a result of the OZI rule. The mechanism is analogous to the one explaining the long life time of the J/Ψ-meson. We should mention, however, a caveat. It turns out that the width of the crypto-exotic states is quite sensitive to the presence of channels involving the η' meson. This is a natural result since the η' meson is closely related to the $U_A(1)$ anomaly giving it large gluonic components. The latter work against the OZI rule. The relevant interaction terms are readily identified

$$\mathcal{L}^{\mathrm{SU(3)}}_{\mathrm{int}} = \frac{i}{\sqrt{6}}\,(3\,h^{\bar{3}}_{31} - h^{\bar{3}}_{39})\,[\bar{D}\,D^\mu + \bar{D}_s D^\mu_s](\partial_\mu \eta') + h.c.$$

$C=0:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
$(\frac{1}{2},\ 0)$	$\pi\,N$	1535 95	0.3	1536 94	0.3
	$\eta\,N$		2.1		2.1
	$K\,\Lambda$		1.7		1.6
	$K\,\Sigma$		3.3		3.3
	$\eta'\,N$		0.0		0.0
	$\eta_c\,N$		0.0		0.0
	$\bar{D}\,\Lambda_c$		0.2		0.2
	$\bar{D}\,\Sigma_c$		0.2		0.2
$(\frac{1}{2},\ 0)$	$\pi\,N$	3327 156	0.1	3520 7.3	0.07
	$\eta\,N$		0.1		0.11
	$K\,\Lambda$		0.1		0.08
	$K\,\Sigma$		0.1		0.08
	$\eta'\,N$		1.4		0.22
	$\eta_c\,N$		0.7		1.0
	$\bar{D}\,\Lambda_c$		0.5		0.05
	$\bar{D}\,\Sigma_c$		5.7		5.3
$(0,-1)$	$\pi\,\Sigma$	1413 10	0.7	1413 10	0.7
	$\bar{K}\,N$		2.7		2.7
	$\eta\,\Lambda$		1.1		1.1
	$K\,\Xi$		0.1		0.1
	$\eta'\Lambda$		0.0		0.0
	$\eta_c\Lambda$		0.0		0.0
	$\bar{D}_s\Lambda_c$		0.2		0.2
	$\bar{D}\,\Xi_c$		0.0		0.0
	$\bar{D}\,\Xi_c'$		0.0		0.0
$(0,-1)$	$\pi\,\Sigma$	1689 35	0.2	1689 35	0.2
	$\bar{K}\,N$		0.6		0.6
	$\eta\,\Lambda$		1.1		1.1
	$K\,\Xi$		3.6		3.6
	$\eta'\Lambda$		0.0		0.0
	$\eta_c\Lambda$		0.0		0.0
	$\bar{D}_s\Lambda_c$		0.1		0.1
	$\bar{D}\,\Xi_c$		0.1		0.1
	$\bar{D}\,\Xi_c'$		0.1		0.1
$(0,-1)$	$\pi\,\Sigma$	3148 1.0	0.04	3234 0.57	0.04
	$\bar{K}\,N$		0.03		0.03
	$\eta\,\Lambda$		0.03		0.03
	$K\,\Xi$		0.04		0.04
	$\eta'\Lambda$		0.08		0.01
	$\eta_c\Lambda$		0.08		0.06
	$\bar{D}_s\Lambda_c$		3.2		3.0
	$\bar{D}\,\Xi_c$		5.0		5.0
	$\bar{D}\,\Xi_c'$		0.1		0.01

Table 5

Spectrum of $J^P = \frac{1}{2}^-$ baryons with charm zero. The 3rd and 4th columns follow with SU(4) symmetric 3-point vertices. In the 5th and 6th columns SU(4) breaking is introduced with $h^{1}_{3\bar{3}} \simeq -1.19\,g$ and $h^{\bar{3}}_{31} = h^{\bar{3}}_{1\bar{3}} \simeq 0.71\,g$. We use $g = 6.6$.

$$-\frac{i}{\sqrt{6}}\,(h^{\bar{3}}_{9\bar{3}} - 3\,h^{\bar{3}}_{1\bar{3}})\,[(\partial_\mu \bar{D})\,D^\mu + (\partial_\mu \bar{D}_s)\,D_s^\mu]\,\eta' + h.c.\,. \tag{35}$$

We emphasize that switching off the t-channel exchange of charm or using the SU(4) estimate for the latter, strongly bound crypto-exotic states are formed. In Tabs. 5-6 the zero-charm spectrum insisting on the SU(4) estimates (17, 20) is shown in the 3rd and 4th column. The mass of the crypto-exotic nucleon resonance comes at 3.33 GeV in this case. Its width of 160 MeV is completely dominated by the $\eta' N$ decay. The properties of that state can be adjusted easily to be consistent with the empirical values claimed in [6]. The η'

$C=0:\ \ (I,\ \ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
$(0,-1)$	$\pi\,\Sigma$	3432 161	0.1	3581 4.9	0.06
	$\bar{K}\,N$		0.0		0.01
	$\eta\,\Lambda$		0.0		0.03
	$K\,\Xi$		0.1		0.07
	$\eta'\,\Lambda$		1.3		0.20
	$\eta_c\Lambda$		0.7		0.93
	$\bar{D}_s\Lambda_c$		0.6		0.05
	$\bar{D}\,\Xi_c$		0.1		0.02
	$\bar{D}\,\Xi'_c$		5.6		5.3
$(1,-1)$	$\pi\,\Lambda$	3602 227	0.1	3930 11	0.08
	$\pi\,\Sigma$		0.1		0.04
	$\bar{K}\,N$		0.2		0.12
	$\eta\,\Sigma$		0.1		0.08
	$K\,\Xi$		0.1		0.06
	$\eta'\Sigma$		1.5		0.27
	$\eta_c\Sigma$		1.2		1.8
	$\bar{D}\,\Xi_c$		0.6		0.11
	$\bar{D}_s\Sigma_c$		4.6		3.6
	$\bar{D}\,\Xi'_c$		2.9		2.4
$(\frac{1}{2},-2)$	$\pi\,\Xi$	1644 3.0	0.1	1644 3.1	0.1
	$\bar{K}\,\Lambda$		0.4		0.4
	$\bar{K}\,\Sigma$		2.8		2.8
	$\eta\,\Xi$		1.3		1.3
	$\eta'\Xi$		0.0		0.0
	$\eta_c\Xi$		0.0		0.0
	$\bar{D}_s\Xi_c$		0.2		0.2
	$\bar{D}_s\Xi'_c$		0.1		0.1
	$\bar{D}\,\Omega_c$		0.0		0.0
$(\frac{1}{2},-2)$	$\pi\,\Xi$	3624 204	0.1	3798 6.0	0.08
	$\bar{K}\,\Lambda$		0.1		0.04
	$\bar{K}\,\Sigma$		0.1		0.04
	$\eta\,\Xi$		0.0		0.01
	$\eta'\Xi$		1.4		0.22
	$\eta_c\Xi$		1.0		1.2
	$\bar{D}_s\Xi_c$		0.6		0.10
	$\bar{D}_s\Xi'_c$		3.3		2.9
	$\bar{D}\,\Omega_c$		4.3		4.0

Table 6
Continuation of Tab. 5.

coupling strength to the open-charm mesons can be turned off by decreasing the magnitude of $h^{\bar{3}}_{31}$ and $h^{\bar{3}}_{1\bar{3}}$ by 33.3 % away from their SU(4) values. As a result the width of the resonance is down to about 1-2 MeV [2]. It is stressed that the masses of the crypto-exotic states are not affected at all. The latter are increased most efficiently by allowing a OZI violating $\phi_\mu\,D\bar{D}$ vertex. We adjust $h^{1}_{\bar{3}\bar{3}} \simeq -1.19\,g$ and $h^{\bar{3}}_{31} = h^{\bar{3}}_{1\bar{3}} \simeq 0.71\,g$ as to obtain the nucleon resonance mass and width at 3.52 GeV and 7 MeV. For all other parameters the SU(4) estimates are used. The result of this choice of parameters is shown in Fig. 1 and in the last two rows of Tabs. 5-6. Further crypto-exotic states, members of the aforementioned octet, are predicted at mass 3.58 GeV $(0,-1)$ and 3.93

[2] We mention that the width of the crypto-exotic states can be reduced also by decreasing the value of the coupling constant $g^{\bar{3}}_{86}$. However, in order to obtain a width for crypto-exotic nucleon resonance of 7 MeV that coupling constant had to be reduced by a factor 4-5.

GeV $(1,-1)$. The multiplet is completed with a $(\frac{1}{2},-2)$ state at 3.80 GeV. The decay widths of these states center around ~ 7 MeV. This reflects the dominance of their decays into channels involving the η' meson. The coupling constants to the various channels are included in Tabs. 5-6. They confirm the interpretation that the crypto-exotic states discussed above are a consequence of a strongly attractive force between the charmed mesons and the baryon sextet.

We continue with a discussion of the crypto-exotic SU(3) singlet state, which is formed due to strong attraction in the $(\bar{D}_s\Lambda_c), (\bar{D}\,\Xi_c)$ system. Its nature is quite different as compared to the one of the octet states. This is because its coupling to the $\eta'\Lambda$ channel is largely suppressed. Indeed its width is independent on the magnitude of $h^{\bar{3}}_{31} = h^{3}_{1\bar{3}}$ as demonstrated in Tabs. 5-6. We identify this state with a signal claimed in the K^-p reaction, where a narrow hyperon state with 3.17 GeV mass and width smaller than 20 MeV was seen [5]. Using values for the coupling constants as suggested by SU(4) the state has a mass and width of 3.148 GeV and 1 MeV (see 3rd and 4th column of Tabs. 5-6). Using our favored parameter set with $h^{1}_{\bar{3}\bar{3}} \simeq -1.19\, g$ and $h^{\bar{3}}_{31} = h^{3}_{1\bar{3}} \simeq 0.71\, g$ the binding energy is decreased by about 80 MeV. The width is slightly reduced.

It is instructive to compute the formation cross section for the $N(3520)$ and $\Lambda(3170)$. Providing the factor 2/3 to (32) as required for the π^-p initial state, the relevant coupling constant of Tabs. 5-6 implies

$$\sigma_{\pi^- p \to N(3520)} = \frac{1\,\mathrm{MeV}}{\Gamma_{N(3520)}}\, 600\,\mu\mathrm{barn}\,, \tag{36}$$

for a given total decay width. This is to be compared with the total cross section $\sigma^{\rm tot}_{\pi^- p} \simeq 25$ mbarn at $\sqrt{s} \simeq 3.5$ GeV [25]. The formation cross section in a K^-p reaction of a the crypto-exotic singlet state is

$$\sigma_{K^- p \to \Lambda(3170)} = \frac{1\,\mathrm{MeV}}{\Gamma_{\Lambda(3170)}}\, 36\,\mu\mathrm{barn}\,, \tag{37}$$

for a given total decay width. This is to be compared with the total cross section $\sigma^{\rm tot}_{K^- p} \simeq 25$ mbarn at $\sqrt{s} \simeq 3.2$ GeV [25]. The empirical width is reported to be smaller than 20 MeV [5]. Note that the initial K^-p state requires an additional factor 1/4 in (32).

Open charm systems are quite intriguing since the channels which have either a charmed baryon or a charmed meson are comparatively close in mass. Unfortunately, at present there is very little empirical information available on open-charm s-wave resonances. Only two states $\Lambda_c(2593), \Xi_c(2790)$ [25] are discovered so far. We claim that the $\Lambda_c(2880)$ observed by the CLEO collaboration [48] can not be a s-wave resonance. This will be substantiated below. In the speeds of Fig. 2 more than 15 well defined resonance states are visible.

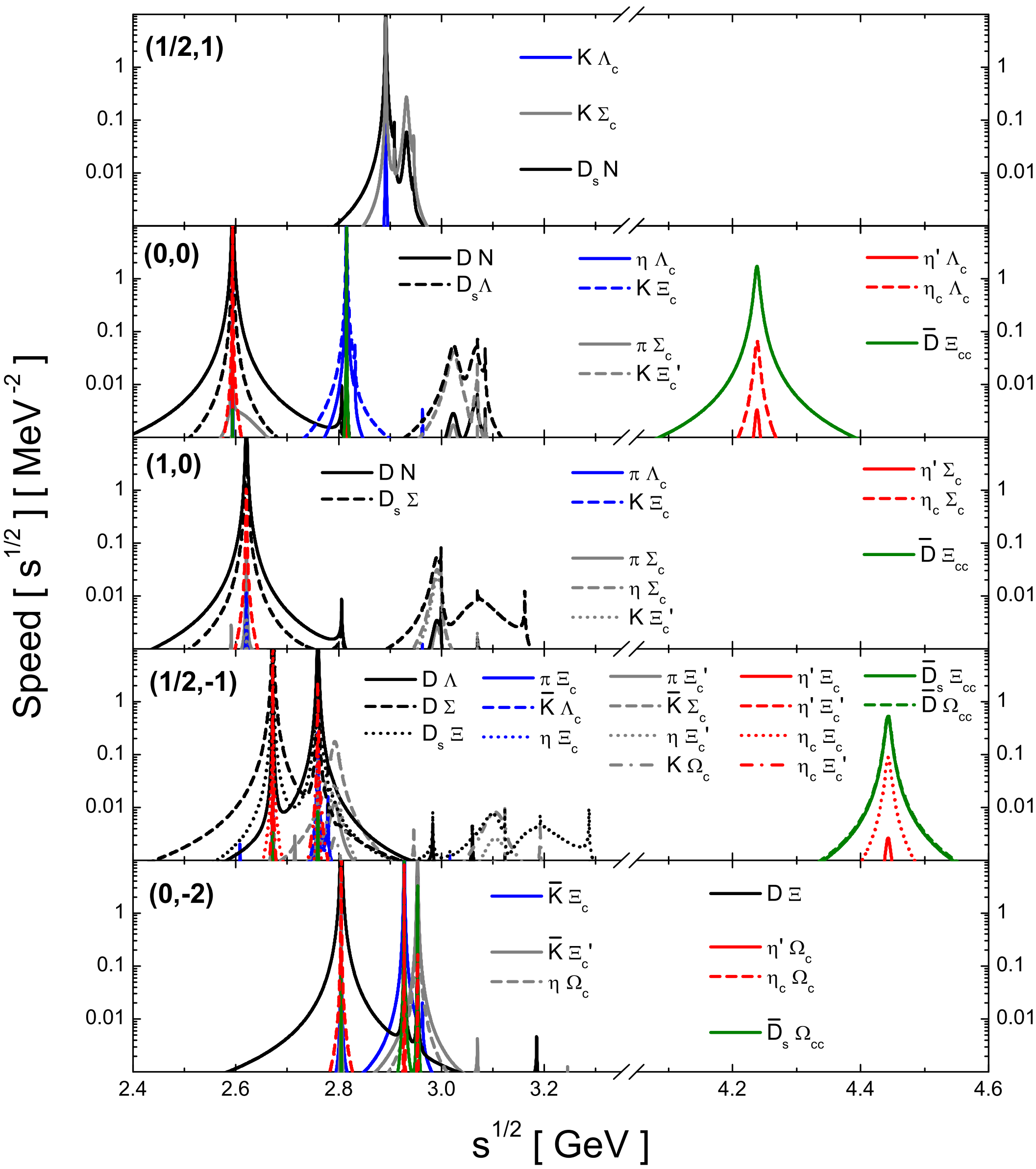

Fig. 2. It is shown the logarithm of the diagonal $\text{Speed}_{aa}(\sqrt{s}\,)$ for channels where resonances form with $C = 1$.

Their properties are listed in Tabs. 7-10. We collect the resonance properties for the two parameter sets used before in the charm minus one and zero sectors. The 3rd and 4th column show the implications of SU(4) symmetric 3-point vertices together with the universal vector coupling constant $g = 6.6$. The 5th and 6th columns follow with the moderate SU(4) breaking relations $h^{1}_{\bar{3}\bar{3}} \simeq -1.19\, g$ and $h^{\bar{3}}_{\bar{3}1} = h^{\bar{3}}_{1\bar{3}} \simeq 0.71\, g$. The speeds shown in Fig. 2 are based on the second set of parameters.

In previous coupled-channel computations the effect of the light pseudo-scalar mesons as they scatter off charmed baryons was studied [7,8]. We confirm the striking prediction of such computations which suggest the existence of strongly bound $\bar{3}, 6$ but also weakly bound $\bar{3}, 6, \overline{15}$ systems. These multiplets are formed by scattering the octet of Goldstone bosons off the baryon anti-triplet and sextet.

$$8 \otimes \bar{3} = \bar{3} \oplus 6 \oplus \overline{15}\,, \qquad 8 \otimes 6 = \bar{3} \oplus 6 \oplus \overline{15} \oplus 24\,. \tag{38}$$

For $8 \otimes \bar{3}$ scattering chiral dynamics predicts attraction in anti-triplet, sextet and repulsion in the $\overline{15}$-plet [7]. For $8 \otimes 6$ scattering attraction is foreseen in anti-triplet, sextet, $\overline{15}$-plet with decreasing strength. Further multiplets are generated by the scattering of the anti-triplet mesons of the octet baryons. The decomposition is given already in (38). In this case we find attraction in the anti-triplet, sextet and the $\overline{15}$-plet. If we switch off the t-channel forces defined by the exchange of heavy vector mesons the three types of resonances discussed above do not communicate with each other. This is a direct consequence of the chiral SU(3) symmetry imposed in (9). It forbids the transition of a anti-triplet baryon into a sextet baryon under the radiation of a light vector meson. Since the exchange of heavy vector mesons is largely suppressed, the SU(4) assumption in (11, 13) has a very minor effect on the resonance spectrum. The coupling constants (17, 20) estimate the small mixing of the three types of states. For the readers' convenience we recall the (I, S) content of the various SU(3) multiplets:

$$[\bar{3}] \ni \begin{pmatrix} (0,0) \\ (\frac{1}{2},-1) \end{pmatrix}, \qquad [6] \ni \begin{pmatrix} (1,0) \\ (\frac{1}{2},-1) \\ (0,-2) \end{pmatrix},$$

$$[\overline{15}] \ni \left(\begin{array}{c} (\frac{1}{2},+1) \\ (0,0),(1,0) \\ (\frac{1}{2},-1),(\frac{3}{2},-1) \\ (1,-2) \end{array} \right) , \qquad [24] \ni \left(\begin{array}{c} (\frac{3}{2},+1) \\ (1,0),(2,0) \\ (\frac{1}{2},-1),(\frac{3}{2},-1) \\ (0,-2),(1,-2) \\ (\frac{1}{2},-3) \end{array} \right) . \tag{39}$$

All together from this discussion we expect the formation of three strongly bound anti-triplet and sextet resonances and two weakly bound $\overline{15}$-plets. It should be emphasized that coupled-channel dynamics tends to distort the multiplet structure that arises in a SU(3) world. Not all members of a multiplet will survive, in particular if there is weak attraction only. The sextet resonances are most easily traced in the $(0,-2)$ sector which is a unique signal of a sextet, given the fact that we expect no 24 resonance. Indeed in this sector three bound states with masses 2.80 GeV, 2.93 GeV and 2.95 GeV are displayed in Fig. 2. The coupling constants given in Tabs. 7-10 confirm the above interpretation. There is a clear hierarchy of binding energies. The states with large coupling constants to the anti-triplet mesons are bound most strongly. The weakest binding is observed for states that couple strongly to the 6 baryons. It is interesting to observe a distortion of that picture in the $(1,0)$ sector, in which the sextet but also the $\overline{15}$-plet manifest themselves. A strongly bound state at around 2.62 GeV couples dominantly to the $\bar{3}$ mesons. The second narrow state around 2.99 GeV is a member of the $\overline{15}$. The chiral excitations of the anti-triplet and sextet baryons are quite broad in this sector [7,8] and therefore not included in Tabs. 7-10. The $\overline{15}$-plet is clearly visible also in the exotic $(\frac{1}{2},-1),(\frac{3}{2},-1),(1,-2)$ sectors with narrow but weakly bound states. Depending on the parameter set we find one or two states with $(\frac{1}{2},-1)$ whereas the $(\frac{3}{2},-1),(1,-2)$ sectors enjoy one state only that couples strongly to the $(D\,\Sigma)$ and $(D_s\,\Xi)$ channels respectively.

The anti-triplet states are identified most easily in the $(0,0)$ sector. The narrow state at 2.593 GeV couples strongly to the anti-triplet mesons. It has properties amazingly consistent with the $\Lambda_c(2593)$ [25]. The empirical width is $3.6^{+2.0}_{-1.3}$ MeV. This narrow state is almost degenerate in mass with a chiral excitation of the triplet baryons [7,8]. The latter can be seen in Fig. 2 but is not included in Tabs. 7-10. It decays dominantly into the $\pi\,\Sigma_c$ channel giving it a width of about 50 MeV. A further narrow state at 2.815 GeV is the second chiral excitation of the anti-triplet baryons [7,8] in this sector. Since it couples strongly to the $\eta\,\Lambda_c(2285)$ channel, one should not associate this state with the $\Lambda_c(2880)$ detected by the CLEO collaboration [48] via its decay into the $\pi\,\Sigma_c(2453)$ channel. The narrow total width of the observed state of smaller than 8 MeV [48] appears inconsistent with a large coupling of that state to the open $\eta\,\Lambda_c$ channel. The chiral excitation of the 6 baryon is quite broad in this

$C=1:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$
$(\frac{1}{2},\ 1)$	$K\,\Lambda_c$	2925	0.02	2932	0.1
	$D_s N$	1.3	0.4	6.9	0.8
	$K\,\Sigma_c$		2.0		1.8
$(\frac{1}{2},\ 1)$	$K\,\Lambda_c$	—		2892	0.1
	$D_s N$			0.6	2.9
	$K\,\Sigma_c$				0.9
$(0,\ 0)$	$\pi\,\Sigma_c$	2609	0.14	2593	0.12
	$D\,N$	0.2	6.3	0.05	6.6
	$\eta\,\Lambda_c$		0.04		0.04
	$K\,\Xi_c$		0.01		0.01
	$K\,\Xi_c'$		0.03		0.02
	$D_s\Lambda$		2.7		2.6
	$\eta'\Lambda_c$		0.11		0.01
	$\eta_c\Lambda_c$		0.62		0.55
	$\bar{D}\,\Xi_{cc}$		0.0		0.0
$(0,\ 0)$	$\pi\,\Sigma_c$	2815	0.0	2815	0.0
	$D\,N$	0.001	0.01	0.0001	0.0
	$\eta\,\Lambda_c$		1.3		1.3
	$K\,\Xi_c$		2.4		2.4
	$K\,\Xi_c'$		0.0		0.0
	$D_s\Lambda$		0.11		0.15
	$\eta'\Lambda_c$		0.0		0.0
	$\eta_c\Lambda_c$		0.02		0.02
	$\bar{D}\,\Xi_{cc}$		0.15		0.16
$(0,\ 0)$	$\pi\,\Sigma_c$	3036	0.5	3023	0.4
	$D\,N$	17	0.1	19	0.5
	$\eta\,\Lambda_c$		0.0		0.1
	$K\,\Xi_c$		0.0		0.1
	$K\,\Xi_c'$		2.2		1.9
	$D_s\Lambda$		0.4		2.2
	$\eta'\Lambda_c$		0.0		0.0
	$\eta_c\Lambda_c$		0.0		0.1
	$\bar{D}\,\Xi_{cc}$		0.0		0.0
$(0,\ 0)$	$\pi\,\Sigma_c$	—		3068	0.3
	$D\,N$			22	0.7
	$\eta\,\Lambda_c$				0.1
	$K\,\Xi_c$				0.1
	$K\,\Xi_c'$				0.8
	$D_s\Lambda$				2.4
	$\eta'\Lambda_c$				0.0
	$\eta_c\Lambda_c$				0.1
	$\bar{D}\,\Xi_{cc}$				0.0
$(0,\ 0)$	$\pi\,\Sigma_c$	4102	0.1	4238	0.04
	$D\,N$	208	0.1	7.3	0.02
	$\eta\,\Lambda_c$		0.0		0.03
	$K\,\Xi_c$		0.1		0.10
	$K\Xi_c'$		0.0		0.03
	$D_s\Lambda$		0.1		0.0
	$\eta'\Lambda_c$		1.3		0.21
	$\eta_c\Lambda_c$		0.7		0.94
	$\bar{D}\,\Xi_{cc}$		4.9		4.8

Table 7
Spectrum of $J^P=\frac{1}{2}^-$ baryons with charm one. The 3rd and 4th columns follow with SU(4) symmetric 3-point vertices. In the 5th and 6th columns SU(4) breaking is introduced with $h^{1}_{\bar{3}\bar{3}}\simeq -1.19\,g$ and $h^{\bar{3}}_{\bar{3}1}=h^{\bar{3}}_{1\bar{3}}\simeq 0.71\,g$. We use $g=6.6$.

sector with mass around 2.65 GeV coupling strongly to the $\pi\Sigma_c$ channel. Most spectacular is the $(\frac{1}{2},-1)$ sector in which we predict 4 narrow states below 4 GeV. The particle data group reports a state $\Xi_c(2790)$ with a decay width

$C=1:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
	$\pi\,\Lambda_c$		0.2		0.2
	$\pi\,\Sigma_c$		0.2		0.2
	$D\,N$		4.9		5.8
	$K\,\Xi_c$		0.1		0.1
$(1,\ 0)$	$\eta\,\Sigma_c$	2680	0.0	2620	0.0
	$K\,\Xi'_c$	3.3	0.1	1.4	0.0
	$D_s\Sigma$		3.6		3.4
	$\eta'\Sigma_c$		0.1		0.0
	$\bar{D}\,\Xi_{cc}$		0.0		0.0
	$\eta_c\Sigma_c$		0.8		0.7
	$\pi\,\Lambda_c$				0.0
	$\pi\,\Sigma_c$				0.5
	$D\,N$				0.5
	$K\,\Xi_c$				0.0
$(1,\ 0)$	$\eta\,\Sigma_c$	—		2992	1.6
	$K\,\Xi'_c$			18	1.4
	$D_s\Sigma$				2.1
	$\eta'\Sigma_c$				0.0
	$\bar{D}\,\Xi_{cc}$				0.1
	$\eta_c\Sigma_c$				0.1
	$\pi\,\Xi_c$		0.06		0.05
	$\pi\,\Xi'_c$		0.04		0.03
	$\bar{K}\,\Lambda_c$		0.04		0.03
	$\bar{K}\,\Sigma_c$		0.13		0.10
	$D\,\Lambda$		0.92		0.93
	$\eta\,\Xi_c$		0.02		0.02
	$D\,\Sigma$		6.9		7.1
$(\frac{1}{2},-1)$	$\eta\,\Xi'_c$	2691	0.04	2672	0.03
	$K\,\Omega_c$	0.09	0.0	0.06	0.0
	$D_s\Xi$		2.9		2.8
	$\eta'\Xi_c$		0.10		0.01
	$\eta'\Xi'_c$		0.02		0.0
	$\eta_c\Xi_c$		0.67		0.60
	$\bar{D}_s\Xi_{cc}$		0.0		0.0
	$\bar{D}\,\Omega_{cc}$		0.0		0.01
	$\eta_c\Xi'_c$		0.2		0.19

Table 8
Continuation of Tab. 7.

smaller than 15 MeV. It is naturally identified with the chiral excitation of the sextet baryon of mass 2.79 GeV and width 16 MeV seen in Fig. 2. From Tabs. 7-10 it follows that this state couples strongly to the $\bar{K}\,\Sigma_c$ and $\eta\,\Xi'_c$ channels.

Crypto-exotic states with $cc\bar{c}$ content are formed by the scattering of the 3-plet mesons with $C=-1$ off the triplet baryons with $C=2$:

$$3 \otimes 3 = \bar{3} \oplus 6\,, \tag{40}$$

where we predict strong attraction in the anti-triplet sector only. The associated narrow states have masses ranging from 4.1 GeV to 4.4 GeV. Like in the case of the crypto-exotic states in the zero-charm sectors these states decay preferably into channels involving the η'. Depending on the parameter set the widths is large about 200-250 MeV or down to few MeV.

$C=1:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
$(\frac{1}{2},-1)$	$\pi\,\Xi_c$	2793 15	0.0	2793 16	0.1
	$\pi\,\Xi_c'$		0.9		0.9
	$\bar K\,\Lambda_c$		0.1		0.1
	$\bar K\,\Sigma_c$		3.4		3.3
	$D\,\Lambda$		0.0		0.3
	$\eta\,\Xi_c$		0.1		0.1
	$D\,\Sigma$		0.1		0.3
	$\eta\,\Xi_c'$		1.3		1.3
	$K\,\Omega_c$		0.4		0.4
	$D_s\Xi$		0.0		0.3
	$\eta'\Xi_c$		0.0		0.0
	$\eta'\Xi_c'$		0.0		0.0
	$\eta_c\Xi_c$		0.0		0.0
	$\bar D_s\Xi_{cc}$		0.1		0.2
	$\bar D\,\Omega_{cc}$		0.0		0.0
	$\eta_c\Xi_c'$		0.0		0.1
$(\frac{1}{2},-1)$	$\pi\,\Xi_c$	2806 6.7	0.3	2759 0.9	0.1
	$\pi\,\Xi_c'$		0.1		0.1
	$\bar K\,\Lambda_c$		0.4		0.4
	$\bar K\,\Sigma_c$		0.7		0.1
	$D\,\Lambda$		4.8		5.2
	$\eta\,\Xi_c$		0.3		0.2
	$D\,\Sigma$		1.8		1.7
	$\eta\,\Xi_c'$		0.2		0.1
	$K\,\Omega_c$		0.1		0.1
	$D_s\Xi$		3.7		3.5
	$\eta'\Xi_c$		0.1		0.0
	$\eta'\Xi_c'$		0.1		0.0
	$\eta_c\Xi_c$		0.3		0.2
	$\bar D_s\Xi_{cc}$		0.0		0.0
	$\bar D\,\Omega_{cc}$		0.0		0.0
	$\eta_c\Xi_c'$		0.8		0.6
$(\frac{1}{2},-1)$	$\pi\,\Xi_c$	3114 42	0.0	3104 43	0.0
	$\pi\,\Xi_c'$		0.7		0.7
	$\bar K\,\Lambda_c$		0.0		0.1
	$\bar K\,\Sigma_c$		0.4		0.3
	$D\,\Lambda$		0.2		0.4
	$\eta\,\Xi_c$		0.0		0.1
	$D\,\Sigma$		0.1		0.3
	$\eta\,\Xi_c'$		1.1		1.1
	$K\,\Omega_c$		2.1		2.0
	$D_s\Xi$		0.4		1.8
	$\eta'\Xi_c$		0.0		0.0
	$\eta'\Xi_c'$		0.0		0.0
	$\eta_c\Xi_c$		0.0		0.1
	$\bar D_s\Xi_{cc}$		0.0		0.0
	$\bar D\,\Omega_{cc}$		0.1		0.1
	$\eta_c\Xi_c'$		0.0		0.1

Table 9
Continuation of Tab. 8.

4.4 S-wave resonances with charm two

Baryon systems with $C = 2$ are very poorly understood at present. There is a single published isospin doublet state claimed by the SELEX collaboration at 3519 MeV [26] that carries zero strangeness. There are hints that this state can not be the ground state with $J^P = \frac{1}{2}^+$ quantum numbers [27]. This is why

$C=1:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$
$(\frac{1}{2},-1)$	$\pi\,\Xi_c$	4274 241	0.1	4443 9	0.1
	$\pi\,\Xi_c'$		0.0		0.0
	$\bar K\,\Lambda_c$		0.1		0.1
	$\bar K\,\Sigma_c$		0.1		0.0
	$D\,\Lambda$		0.1		0.0
	$\eta\,\Xi_c$		0.1		0.1
	$D\,\Sigma$		0.1		0.0
	$\eta\,\Xi_c'$		0.0		0.0
	$K\,\Omega_c$		0.0		0.0
	$D_s\Xi$		0.1		0.0
	$\eta'\Xi_c$		1.4		0.2
	$\eta'\Xi_c'$		0.0		0.0
	$\eta_c\Xi_c$		0.9		1.3
	$\bar D_s\Xi_{cc}$		3.5		3.2
	$\bar D\,\Omega_{cc}$		3.5		3.3
	$\eta_c\Xi_c'$		0.0		0.0
$(\frac{3}{2},-1)$	$\pi\,\Xi_c$	—		3052 15	0.2
	$\pi\,\Xi_c'$				0.3
	$\bar K\,\Sigma_c$				0.4
	$D\,\Sigma$				2.5
$(0,-2)$	$\bar K\,\Xi_c$	2839 0	0.4	2805 0	0.3
	$\bar K\,\Xi_c'$		0.2		0.1
	$D\,\Xi$		6.6		6.9
	$\eta\,\Omega_c$		0.1		0.1
	$\eta'\,\Omega_c$		0.1		0.0
	$\bar D_s\Omega_{cc}$		0.0		0.0
	$\eta_c\Omega_c$		0.8		0.7
$(0,-2)$	$\bar K\,\Xi_c$	2928 0	2.3	2927 0	2.3
	$\bar K\,\Xi_c'$		0.1		0.1
	$D\,\Xi$		0.7		0.4
	$\eta\,\Omega_c$		0.1		0.1
	$\eta'\,\Omega_c$		0.0		0.0
	$\bar D_s\Omega_{cc}$		0.4		0.4
	$\eta_c\Omega_c$		0.1		0.1
$(0,-2)$	$\bar K\,\Xi_c$	2953 0	0.1	2953 0	0.0
	$\bar K\,\Xi_c'$		2.5		2.5
	$D\,\Xi$		0.3		0.2
	$\eta\,\Omega_c$		1.8		1.8
	$\eta'\,\Omega_c$		0.0		0.0
	$\bar D_s\Omega_{cc}$		0.2		0.2
	$\eta_c\Omega_c$		0.1		0.1
$(1,-2)$	$\pi\,\Omega_c$	—		3815 5	0.2
	$\bar K\,\Xi_c$				0.2
	$\bar K\,\Xi_c'$				0.2
	$D\,\Xi$				1.6

Table 10
Continuation of Tab. 9.

we postulated the somewhat ad-hoc mass of 3440 MeV for the ground state Ξ_{cc}. Similarly the results of this section depend on our assumption for the Ω_{cc} mass guessed at 3560 MeV.

There are three types of molecules formed in the coupled-channel computations. The chiral excitations of the 3 baryons with $C=2$ form a strongly bound triplet resonances and a less bound sextet resonance. This part of the spectrum is analogous to the one of the chiral excitations of open-charm mesons: attraction is predicted in the triplet and anti-sextet sectors [9,10]:

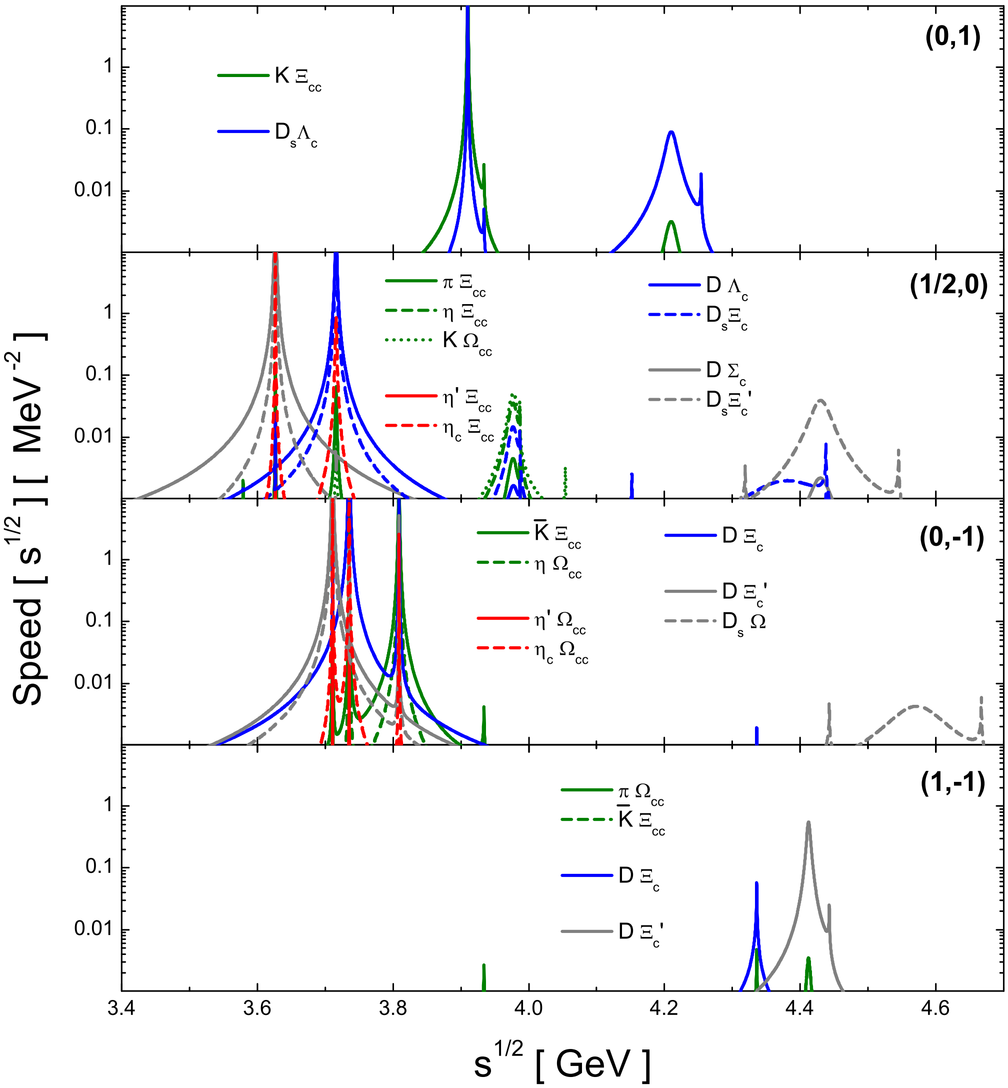

Fig. 3. It is shown the logarithm of the diagonal $\text{Speed}_{aa}(\sqrt{s}\,)$ for channels where resonances form with $C = 2$.

$$8 \otimes 3 = 3 \oplus \bar{6} \oplus 15\,, \qquad \bar{3} \otimes \bar{3} = 3 \oplus \bar{6}\,, \qquad \bar{3} \otimes 6 = 3 \oplus 15\,. \tag{41}$$

Further molecules are formed by the systems composed of open-charm mesons and open-charm baryons. The multiplet decomposition for the anti-triplet and sextet baryons is given also in (41). Strong attraction is predicted in both cases in the triplet, whereas the higher multiplets sextet and $\overline{15}$-plet enjoy weak attraction only. For the readers' convenience we recall the isospin strangeness content of the various multiplets:

$C=2:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
$(0,\ 1)$	$K\,\Xi_{cc}$	3912	2.0	3910	2.0
	$D_s\Lambda_c$	0	0.5	0	0.8
$(0,\ 1)$	$K\,\Xi_{cc}$	—		4210	0.5
	$D_s\Lambda_c$			18	2.7
$(1,\ 1)$	$K\,\Xi_{cc}$	—		4300	0.2
	$D_s\Sigma_c$			3.5	3.4
$(\frac{1}{2},\ 0)$	$\pi\,\Xi_{cc}$	3641	0.05	3626	0.05
	$\eta\,\Xi_{cc}$	0.06	0.02	0.04	0.02
	$K\,\Omega_{cc}$		0.02		0.01
	$D\,\Lambda_c$		0.02		0.02
	$D\,\Sigma_c$		6.2		6.3
	$\eta'\Xi_{cc}$		0.07		0.01
	$D_s\Xi_c$		0.01		0.01
	$D_s\Xi'_c$		2.6		2.6
	$\eta_c\Xi_{cc}$		0.44		0.41
$(\frac{1}{2},\ 0)$	$\pi\,\Xi_{cc}$	3759	0.2	3716	0.2
	$\eta\,\Xi_{cc}$	1.9	0.0	1.8	0.0
	$K\,\Omega_{cc}$		0.1		0.1
	$D\,\Lambda_c$		4.6		5.0
	$D\,\Sigma_c$		0.1		0.1
	$\eta'\Xi_{cc}$		0.2		0.0
	$D_s\Xi_c$		3.4		3.3
	$D_s\Xi'_c$		0.0		0.0
	$\eta_c\Xi_{cc}$		1.0		0.8
$(\frac{1}{2},\ 0)$	$\pi\,\Xi_{cc}$	3979	0.5	3977	0.5
	$\eta\,\Xi_{cc}$	14	1.3	14	1.3
	$K\,\Omega_{cc}$		1.5		1.6
	$D\,\Lambda_c$		0.1		0.2
	$D\,\Sigma_c$		0.0		0.0
	$\eta'\Xi_{cc}$		0.0		0.0
	$D_s\Xi_c$		0.5		0.8
	$D_s\Xi'_c$		0.1		0.1
	$\eta_c\Xi_{cc}$		0.0		0.0
$(\frac{1}{2},\ 0)$	$\pi\,\Xi_{cc}$	—		4430	0.0
	$\eta\,\Xi_{cc}$			32	0.2
	$K\,\Omega_{cc}$				0.2
	$D\,\Lambda_c$				0.1
	$D\,\Sigma_c$				0.8
	$\eta'\Xi_{cc}$				0.0
	$D_s\Xi_c$				0.0
	$D_s\Xi'_c$				3.2
	$\eta_c\Xi_{cc}$				0.1

Table 11
Spectrum of $J^P=\frac{1}{2}^-$ baryons with charm two. The 3rd and 4th columns follow with SU(4) symmetric 3-point vertices. In the 5th and 6th columns SU(4) breaking is introduced with $h^{1}_{\bar{3}\bar{3}} \simeq -1.19\,g$ and $h^{\bar{3}}_{\bar{3}1} = h^{\bar{3}}_{1\bar{3}} \simeq 0.71\,g$. We use $g = 6.6$.

$$[3] \ni \begin{pmatrix} (\frac{1}{2},0) \\ (0,-1) \end{pmatrix} , \quad [\bar{6}] \ni \begin{pmatrix} (0,+1) \\ (\frac{1}{2},0) \\ (1,-1) \end{pmatrix} , \quad [15] \ni \begin{pmatrix} (1,+1) \\ (\frac{1}{2},0)\,,(\frac{3}{2},0) \\ (0,-1)\,,(1,-1) \\ (\frac{1}{2},-2) \end{pmatrix} . \tag{42}$$

All together we expect 6 states with $(\frac{1}{2},0)$ quantum numbers. Given the pos-

$C=2:\ (I,\ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R \rvert$
$(\frac{3}{2},\ 0)$	$\pi\,\Xi_{cc}$	—		4251	0.2
	$D\,\Sigma_c$			4.6	2.9
$(0,-1)$	$\bar{K}\,\Xi_{cc}$	3726	0.1	3711	0.1
	$\eta\,\Omega_{cc}$	0	0.0	0	0.0
	$D\,\Xi_c$		0.1		0.1
	$D\,\Xi_c'$		5.5		5.6
	$\eta'\Omega_{cc}$		0.1		0.0
	$D_s\Omega_c$		4.0		3.7
	$\eta_c\Omega_{cc}$		0.5		0.5
$(0,-1)$	$\bar{K}\,\Xi_{cc}$	3761	0.6	3735	0.3
	$\eta\,\Omega_{cc}$	0	0.3	0	0.2
	$D\,\Xi_c$		5.9		6.2
	$D\,\Xi_c'$		0.0		0.1
	$\eta'\Omega_{cc}$		0.1		0.0
	$D_s\Omega_c$		0.0		0.0
	$\eta_c\Omega_{cc}$		0.9		0.8
$(0,-1)$	$\bar{K}\,\Xi_{cc}$	3810	2.6	3809	2.7
	$\eta\,\Omega_{cc}$	0	1.2	0	1.2
	$D\,\Xi_c$		1.1		0.7
	$D\,\Xi_c'$		0.2		0.1
	$\eta'\Omega_{cc}$		0.0		0.0
	$D_s\Omega_c$		0.2		0.2
	$\eta_c\Omega_{cc}$		0.2		0.1
$(0,-1)$	$\bar{K}\,\Xi_{cc}$	—		4571	0.2
	$\eta\,\Omega_{cc}$			90	0.3
	$D\,\Xi_c$				0.1
	$D\,\Xi_c'$				1.2
	$\eta'\Omega_{cc}$				0.0
	$D_s\Omega_c$				2.9
	$\eta_c\Omega_{cc}$				0.2
$(1,-1)$	$\pi\,\Omega_{cc}$	—		4412	0.2
	$\bar{K}\,\Xi_{cc}$			6	0.2
	$D\,\Xi_c$				0.0
	$D\,\Xi_c'$				2.3
$(\frac{1}{2},-2)$	$\bar{K}\,\Omega_{cc}$	—		4562	0.2
	$D\,\Omega_c$			4	1.3

Table 12
Continuation of Tab. 11.

tulated values for the masses of the 3 baryons, the lowest $(\frac{1}{2},0)$ state is predicted at mass around 3.63-3.64 GeV depending on the parameter set. That state couples preferably to the $(D\,\Sigma_c)$ and $(D_s\Xi_c')$ states, but very weakly to the $(D\,\Lambda_c)$ channel. Therefore it should not be identified with the SELEX Ξ_{cc}^+ state at 3519 MeV, which was observed by its decay into $\Lambda_c^+\,K^-\,\pi^+$ [26]. A further resonance of the $(D\,\Lambda_c),(D_s\Xi_c)$ system is formed at 3.72-3.76 GeV. Its mass is much to high as to associate it with the SELEX state. If the SELEX state had $\frac{1}{2}^-$ quantum numbers it poses certainly a puzzle to us. The first chiral excitation with a width of about 200 MeV is predicted at mass 3.65 GeV. It decays into the open $\pi\,\Xi_{cc}$ channel. Due to its broad width that resonance is not listed in Tabs. 11-12. The narrow chiral excitation at around 3.98 GeV, which couples strongly to the $(\eta\,\Xi_{cc}),(K\,\Omega_{cc})$ channels, reflects the attraction predicted in the anti-sextet. Two further $(\frac{1}{2},0)$ states may arise from the weak attraction of the open-charm mesons and open-charm baryons in the anti-sextet and 15-plet. The formation of those states depends on the details

$C=3:\ \ (I,\ \ S)$	state	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$	M_R[MeV] Γ_R [MeV]	$\lvert g_R\rvert$
(0, 0)	$D\,\Xi_{cc}$	4325	5.5	4308	5.6
	$D_s\Omega_{cc}$	0	2.8	0	2.8

Table 13
Spectrum of $J^P=\frac{1}{2}^-$ baryons with charm three. The 3rd and 4th columns follow with SU(4) symmetric 3-point vertices. In the 5th and 6th columns SU(4) breaking is introduced with $h^{1}_{\bar{3}3} \simeq -1.19\,g$ and $h^{\bar{3}}_{\bar{3}1} = h^{\bar{3}}_{1\bar{3}} \simeq 0.71\,g$. We use $g = 6.6$.

of the parameter choice. For SU(4) symmetric 3-point vertices no clear signals are seen in that anti-sextet and 15-plet. However, with the SU(4) breaking pattern used before a broad anti-sextet state at 4.38 GeV, that decays into the open $(D\,\Lambda_c)$ channel, is formed. The 15-plet manifests itself with a state at 4.43 GeV of width about 30 MeV.

The hierarchy observed for the binding energies of triplet states with $(\frac{1}{2},0)$ quantum numbers is confirmed by the $(0,-1)$ states belonging to the 3. We predict three bound states at (3.71, 3.74, 3.81) GeV for the parameter set with SU(4) breaking. A further state, necessarily a member of the 15-plet is predicted at 4.57 GeV with a width of 90 MeV. We turn to the $(0,+1)$ and $(1,-1)$ sectors. The first probes uniquely the 6. Indeed we find two states with $(0,+1)$ at 3.91 GeV and 4.21 GeV. Again the chiral excitation is bound stronger than the state coupling formed by the interaction of the D_s with the Λ_c. In the $(1,-1)$ sector we expect three states. A narrow signal is seen at 4.41 GeV only, which is a member of the 15-plet. The two states belonging to the two 6 multiplets are masked by coupled channel effects. No clear signals are predicted. It remains to discuss the three exotic sectors $(1,+1), (\frac{3}{2},0), (\frac{1}{2},-2)$, all probing exclusively the 15-plet. As described above, the attraction in the 15-plet is sufficiently strong to form a resonance multiplet only, if a SU(4) breaking pattern is allowed. As shown in the 4th and 5th columns of Tabs. 11-12, weakly bound states are generated in the before mentioned sectors.

4.5 S-wave resonances with charm three

We close the result section with a presentation of baryon states with $C=3$. They are formed by scattering the triplet baryons with $C=2$ of the anti-triplet mesons with $C=1$. According to the decomposition $3\otimes\bar{3} = 1\oplus 8$ only a SU(3) singlet or octet may arise. As demonstrated in Tab. 13 we predict attraction in the singlet only with a bound state of mass 4.31-4.33 GeV depending on the parameter set.

5 Summary

We have performed a coupled-channel study of s-wave baryon resonances with charm $-1, 0, 1, 2, 3$. A rich spectrum is predicted in terms of a t-channel force defined by the exchange of light vector mesons. All relevant coupling constants are obtained from chiral and large-N_c properties of QCD. Less relevant vertices related to the t-channel forces induced by the exchange of charmed vector mesons were estimated by applying SU(4) symmetry. We pointed out that the decay process $D_+(2010) \to \pi_+ \, D_0(1865)$ and the $\rho_+(770) \to \pi_0 \, \pi_+$ can be described by a SU(4) symmetric vertex, where only moderate SU(4) breaking effects are required. As an amusing byproduct it was demonstrated that the KSFR relation [30,31,32] can be viewed as consequence of a 3-point vector-pseudoscalar-meson vertex that is SU(4) symmetric. The results of this work should be taken cautiously since it remains to study the effect of additional terms in the interaction kernel.

Most spectacular is the prediction of narrow crypto-exotic baryons with charm zero forming below 4 GeV. Such states contain a $c\bar{c}$ pair. Their widths parameters are small due to the OZI rule, like it is the case for the J/Ψ meson. We predict an octet of crypto-exotic states which decay dominantly into channels involving an η' meson. An even stronger bound crypto-exotic SU(3) singlet state is predicted to have a decay width of about 1 MeV only. We recover the masses and widths of a crypto-exotic nucleon and hyperon resonance suggested in high statistic bubble chamber experiments [5,6]. We confirm the expectation of Lipkin [40] that penta-quark type states exists with charm minus one. Binding is predicted only in systems with strangeness minus one and minus two. In the charm one sector more than ten so far unobserved narrow states are predicted. Further narrow s-wave states are foreseen in the charm two and three sectors.

Our predictions can be tested experimentally in part by existing collaborations like SELEX or BELLE. We urge the QCD lattice community to perform unquenched simulations in order to verify or disprove the existence of the predicted states. Such studies are of great importance since they will shed more light on how confinement is realized in nature. The central question - what are the most relevant degrees of freedom responsible for the formation of resonances in QCD - can be studied best in systems involving light and heavy quarks simultaneously. The spectrum of open-charm baryons could be a topic of interest for the FAIR project at GSI.

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6 Appendix A

$(I,\ S)$	(a,b)	V	$C^{(I,S,-1)}_{V,ab}$ charm minus one
$(0,+0)$	$(1,1)$	ρ	$\frac{3}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{3}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}-g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(1,+0)$	$(1,1)$	ρ	$-\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}-\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}-g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(\frac{1}{2},-1)$	$(1,1)$	ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{88}\,h^{9}_{\bar3\bar3}+g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
	$(1,2)$	ρ	$\sqrt{\frac{3}{2}}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\sqrt{\frac{1}{6}}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
	$(1,3)$	K^*	$\sqrt{\frac{3}{2}}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}-\sqrt{\frac{3}{2}}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
	$(2,2)$	ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+\frac{4}{3}\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{3}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+\frac{8}{3}\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+\frac{4}{3}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
	$(2,3)$	ρ	$-g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
	$(3,3)$	ρ	$2\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+4\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(\frac{3}{2},-1)$	$(1,1)$	ρ	$-g^{9-}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+4\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(0,-2)$	$(1,1)$	ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+\frac{4}{3}\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{88}\,h^{9}_{\bar3\bar3}+\frac{2}{3}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+\frac{8}{3}\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
	$(1,2)$	K^*	$\sqrt{3}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}-\sqrt{\frac{1}{3}}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
	$(2,2)$	ρ	$\frac{3}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}-\frac{3}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}-\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(1,-2)$	$(1,1)$	ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+4\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{88}\,h^{9}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
	$(1,2)$	K^*	$-g^{9-}_{88}\,h^{9}_{\bar3\bar3}-g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
	$(2,2)$	ρ	$-\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}-\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+g^{1}_{88}\,h^{9}_{\bar3\bar3}+g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$
$(\frac{1}{2},-3)$	$(1,1)$	ω	$4\,g^{1}_{88}\,h^{1}_{\bar3\bar3}-2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{88}\,h^{9}_{\bar3\bar3}-g^{9-}_{88}\,h^{9}_{\bar3\bar3}+g^{9+}_{88}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9-}_{88}\,h^{1}_{\bar3\bar3}+2\,g^{9+}_{88}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{88}\,h^{0}_{\bar3\bar3}$

Table 14

The coupled-channel structure of the t-channel exchange in (21).

$(I,\ S)$	(a,b)	V	$C^{(I,S,0)}_{V,ab}$ charm zero
$(0,+1)$	$(1,1)$	ρ	$3\,g^{9-}_{88}\,h^{9}_{99}+3\,g^{9+}_{88}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{88}\,h^{9}_{99}-g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9-}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
$(1,+1)$	$(1,1)$	ρ	$-g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{88}\,h^{9}_{99}-g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9-}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
$(\frac{1}{2},+0)$	$(1,1)$	ρ	$4\,g^{9-}_{88}\,h^{9}_{99}+4\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,3)$	K^*	$-3\,g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
	$(1,4)$	K^*	$g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
	$(1,7)$	D^*	$-\sqrt{\frac{3}{32}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}-\sqrt{\frac{3}{32}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(1,8)$	D^*	$\sqrt{\frac{1}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(2,3)$	K^*	$-3\,g^{9-}_{88}\,h^{9}_{99}-g^{9+}_{88}\,h^{9}_{99}$
	$(2,4)$	K^*	$-3\,g^{9-}_{88}\,h^{9}_{99}+3\,g^{9+}_{88}\,h^{9}_{99}$
	$(2,7)$	D^*	$-\frac{\sqrt6}{24}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}-\frac{\sqrt6}{24}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(2,8)$	D^*	$-\sqrt{\frac{1}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}-\sqrt{\frac{1}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(3,3)$	ω	$-2\,g^{1}_{88}\,h^{9}_{99}-\frac{2}{3}\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99}+\frac{8}{3}\,g^{9+}_{88}\,h^{9}_{99}$
	$(3,4)$	ρ	$-2\,g^{9+}_{88}\,h^{9}_{99}$
	$(3,7)$	D^*_s	$\sqrt{\frac{1}{24}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{24}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(4,4)$	ρ	$4\,g^{9-}_{88}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99}$
	$(4,8)$	D^*	$\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(5,7)$	D^*	$-\sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{1\bar3}-\sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar31}+\sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(5,8)$	D^*	$-\frac{3}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{1\bar3}-\frac{3}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar31}+\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(6,7)$	D^*	$\sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{0\bar3}+\sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar30}$
	$(6,8)$	D^*	$\sqrt{\frac{3}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{0\bar3}+\sqrt{\frac{3}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar30}$
	$(7,7)$	ω	$4\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+2\,g^{9}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+g^{1}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+g^{1}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{\bar3\bar3}\,h^{0}_{\bar3\bar3}$
	$(7,8)$	ρ	$-\sqrt{\frac{3}{4}}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
	$(8,8)$	ρ	$g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{9}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
$(\frac{3}{2},+0)$	$(1,1)$	ρ	$-2\,g^{9-}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,2)$	K^*	$-2\,g^{9-}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,3)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}-\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(2,2)$	ρ	$-2\,g^{9-}_{88}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99}$
	$(2,3)$	D^*_s	$\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(3,3)$	ρ	$-\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{9}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$

Table 15
Continuation of Tab. 14.

$(I,\ S)$	(a,b)	V	$C^{(I,S,0)}_{V,ab}$ charm zero
$(0,-1)$	$(1,1)$	ρ	$8\, g^{9-}_{88}\, h^{9}_{99}$
	$(1,2)$	K^*	$\sqrt{6}\, g^{9-}_{88}\, h^{9}_{99} - \sqrt{6}\, g^{9+}_{88}\, h^{9}_{99}$
	$(1,4)$	K^*	$-\sqrt{6}\, g^{9-}_{88}\, h^{9}_{99} - \sqrt{6}\, g^{9+}_{88}\, h^{9}_{99}$
	$(1,8)$	D^*	$-\sqrt{\frac{3}{4}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{3}{4}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(1,9)$	D^*	$-\sqrt{\frac{3}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{3}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$3\, g^{9-}_{88}\, h^{9}_{99} + 3\, g^{9+}_{88}\, h^{9}_{99}$
		ω	$2\, g^{1}_{88}\, h^{9}_{99} + g^{9-}_{88}\, h^{9}_{99} + g^{9+}_{88}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{88}\, h^{9}_{99} + 2\, g^{9-}_{88}\, h^{9}_{99} - 2\, g^{9+}_{88}\, h^{9}_{99}$
	$(2,3)$	K^*	$3\,\sqrt{2}\, g^{9-}_{88}\, h^{9}_{99} + \sqrt{2}\, g^{9+}_{88}\, h^{9}_{99}$
	$(2,7)$	D^*	$-\sqrt{\frac{1}{8}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,4)$	K^*	$-3\,\sqrt{2}\, g^{9-}_{88}\, h^{9}_{99} + \sqrt{2}\, g^{9+}_{88}\, h^{9}_{99}$
	$(3,7)$	D^*_s	$-\frac{1}{6}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{6}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,8)$	D^*	$-\frac{1}{12\sqrt{2}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{12\sqrt{2}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,9)$	D^*	$\sqrt{\frac{1}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(4,4)$	ρ	$3\, g^{9-}_{88}\, h^{9}_{99} - 3\, g^{9+}_{88}\, h^{9}_{99}$
		ω	$-2\, g^{1}_{88}\, h^{9}_{99} + g^{9-}_{88}\, h^{9}_{99} - g^{9+}_{88}\, h^{9}_{99}$
		ϕ	$2\, g^{1}_{88}\, h^{9}_{99} + 2\, g^{9-}_{88}\, h^{9}_{99} + 2\, g^{9+}_{88}\, h^{9}_{99}$
	$(4,8)$	D^*_s	$\frac{1}{4}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{4}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(4,9)$	D^*_s	$-\frac{1}{4}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{4}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,7)$	D^*_s	$\sqrt{\frac{1}{2}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{1\bar{3}} + \sqrt{\frac{1}{2}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}1} - \sqrt{\frac{1}{18}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{18}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,8)$	D^*	$-\frac{1}{2}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{1\bar{3}} - \frac{1}{2}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}1} + \frac{1}{6}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{6}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,9)$	D^*	$\frac{3}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{1\bar{3}} + \frac{3}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}1} - \frac{1}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(6,7)$	D^*_s	$-\sqrt{\frac{1}{12}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{0\bar{3}} - \sqrt{\frac{1}{12}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}0}$
	$(6,8)$	D^*	$\sqrt{\frac{1}{24}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{0\bar{3}} + \sqrt{\frac{1}{24}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}0}$
	$(6,9)$	D^*	$-\sqrt{\frac{3}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{0\bar{3}} - \sqrt{\frac{3}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}0}$
	$(7,7)$	ω	$4\, g^{1}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + 2\, g^{9}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + 2\, g^{1}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}} + g^{9}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$2\, g^{1}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}}$
		J/Ψ	$g^{0}_{\bar{3}\bar{3}}\, h^{0}_{\bar{3}\bar{3}}$
	$(7,8)$	K^*	$\sqrt{\frac{1}{2}}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}}$
	$(7,9)$	K^*	$-\sqrt{\frac{1}{2}}\, g^{9}_{\bar{3}6}\, h^{9}_{\bar{3}\bar{3}}$
	$(8,8)$	ρ	$\frac{3}{4}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}}$
		ω	$4\, g^{1}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{4}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$2\, g^{1}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{\bar{3}\bar{3}}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{2}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$g^{0}_{\bar{3}\bar{3}}\, h^{0}_{\bar{3}\bar{3}}$
	$(8,9)$	ρ	$\frac{3}{4}\, g^{9}_{\bar{3}6}\, h^{9}_{\bar{3}\bar{3}}$
		ω	$g^{9}_{\bar{3}6}\, h^{1}_{\bar{3}\bar{3}} + \frac{1}{4}\, g^{9}_{\bar{3}6}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$g^{9}_{\bar{3}6}\, h^{1}_{\bar{3}\bar{3}} - \frac{1}{2}\, g^{9}_{\bar{3}6}\, h^{9}_{\bar{3}\bar{3}}$
	$(9,9)$	ρ	$\frac{3}{4}\, g^{9}_{66}\, h^{9}_{\bar{3}\bar{3}}$
		ω	$4\, g^{1}_{66}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{66}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{66}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{4}\, g^{9}_{66}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$2\, g^{1}_{66}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{66}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{66}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{2}\, g^{9}_{66}\, h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$g^{0}_{66}\, h^{0}_{\bar{3}\bar{3}}$
$(1,-1)$	$(1,2)$	ρ	$-\sqrt{\frac{32}{3}}\, g^{9+}_{88}\, h^{9}_{99}$
	$(1,3)$	K^*	$\sqrt{6}\, g^{9-}_{88}\, h^{9}_{99} + \sqrt{\frac{2}{3}}\, g^{9+}_{88}\, h^{9}_{99}$
	$(1,5)$	K^*	$\sqrt{6}\, g^{9-}_{88}\, h^{9}_{99} - \sqrt{\frac{2}{3}}\, g^{9+}_{88}\, h^{9}_{99}$
	$(1,8)$	D^*	$\frac{1}{4\sqrt{6}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{4\sqrt{6}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(1,10)$	D^*	$-\sqrt{\frac{3}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{3}{32}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$4\, g^{9-}_{88}\, h^{9}_{99}$

Table 16
Continuation of Tab. 15.

$(I,\ S)$	(a,b)	V	$C^{(I,S,0)}_{V,ab}$ charm zero
$(1,-1)$	$(2,3)$	K^*	$2\,g^{9-}_{88}\,h^{9}_{99} - 2\,g^{9+}_{88}\,h^{9}_{99}$
	$(2,5)$	K^*	$-2\,g^{9-}_{88}\,h^{9}_{99} - 2\,g^{9+}_{88}\,h^{9}_{99}$
	$(2,8)$	D^*	$-\frac{1}{4}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39} - \frac{1}{4}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(2,10)$	D^*	$-\frac{1}{4}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \frac{1}{4}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(3,3)$	ρ	$-g^{9-}_{88}\,h^{9}_{99} - g^{9+}_{88}\,h^{9}_{99}$
		ω	$2\,g^{1}_{88}\,h^{9}_{99} + g^{9-}_{88}\,h^{9}_{99} + g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99} + 2\,g^{9-}_{88}\,h^{9}_{99} - 2\,g^{9+}_{88}\,h^{9}_{99}$
	$(3,4)$	K^*	$\sqrt{6}\,g^{9-}_{88}\,h^{9}_{99} - \sqrt{6}\,g^{9+}_{88}\,h^{9}_{99}$
	$(3,9)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(4,5)$	K^*	$\sqrt{6}\,g^{9-}_{88}\,h^{9}_{99} + \sqrt{6}\,g^{9+}_{88}\,h^{9}_{99}$
	$(4,8)$	D^*	$\frac{1}{4\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39} + \frac{1}{4\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(4,9)$	D^*_s	$-\sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(4,10)$	D^*	$\frac{1}{4\sqrt{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} + \frac{1}{4\sqrt{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(5,5)$	ρ	$-g^{9-}_{88}\,h^{9}_{99} + g^{9+}_{88}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{88}\,h^{9}_{99} + g^{9-}_{88}\,h^{9}_{99} - g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{88}\,h^{9}_{99} + 2\,g^{9-}_{88}\,h^{9}_{99} + 2\,g^{9+}_{88}\,h^{9}_{99}$
	$(5,8)$	D^*_s	$\frac{1}{4}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39} + \frac{1}{4}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(5,10)$	D^*_s	$-\frac{1}{4}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \frac{1}{4}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(6,8)$	D^*	$\sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar31} - \sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39} - \sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(6,9)$	D^*_s	$\sqrt{\frac{3}{2}}\,g^{\bar3}_{86}\,h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{2}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar31} - \sqrt{\frac{1}{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \sqrt{\frac{1}{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(6,10)$	D^*	$\sqrt{\frac{3}{4}}\,g^{\bar3}_{86}\,h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{4}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar31} - \sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} - \sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(7,8)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{0\bar3} - \sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar30}$
	$(7,9)$	D^*_s	$-\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{0\bar3} - \frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar30}$
	$(7,10)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{0\bar3} - \sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar30}$
	$(8,8)$	ρ	$-\frac{1}{4}\,g^{9}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3} + g^{9}_{\bar3\bar3}\,h^{1}_{\bar3\bar3} + g^{1}_{\bar3\bar3}\,h^{9}_{\bar3\bar3} + \frac{1}{4}\,g^{9}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3} + g^{9}_{\bar3\bar3}\,h^{1}_{\bar3\bar3} + g^{1}_{\bar3\bar3}\,h^{9}_{\bar3\bar3} + \frac{1}{2}\,g^{9}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{\bar3\bar3}\,h^{0}_{\bar3\bar3}$
	$(8,9)$	K^*	$-\sqrt{\frac{1}{2}}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
	$(8,10)$	ρ	$-\frac{1}{4}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
		ω	$g^{9}_{\bar36}\,h^{1}_{\bar3\bar3} + \frac{1}{4}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
		ϕ	$-g^{9}_{\bar36}\,h^{1}_{\bar3\bar3} - \frac{1}{2}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
	$(9,9)$	ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3} + 2\,g^{9}_{66}\,h^{1}_{\bar3\bar3} + 2\,g^{1}_{66}\,h^{9}_{\bar3\bar3} + g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
	$(9,10)$	K^*	$\sqrt{\frac{1}{2}}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
	$(10,10)$	ρ	$-\frac{1}{4}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3} + g^{9}_{66}\,h^{1}_{\bar3\bar3} + g^{1}_{66}\,h^{9}_{\bar3\bar3} + \frac{1}{4}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3} + g^{9}_{66}\,h^{1}_{\bar3\bar3} + g^{1}_{66}\,h^{9}_{\bar3\bar3} + \frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
$(2,-1)$	$(1,1)$	ρ	$-4\,g^{9-}_{88}\,h^{9}_{99}$
$(\frac{1}{2},-2)$	$(1,1)$	ρ	$4\,g^{9-}_{88}\,h^{9}_{99} - 4\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,2)$	K^*	$3\,g^{9-}_{88}\,h^{9}_{99} - g^{9+}_{88}\,h^{9}_{99}$
	$(1,3)$	K^*	$g^{9-}_{88}\,h^{9}_{99} + g^{9+}_{88}\,h^{9}_{99}$
	$(1,9)$	D^*	$\sqrt{\frac{3}{16}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39} + \sqrt{\frac{3}{16}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(2,2)$	ω	$2\,g^{1}_{88}\,h^{9}_{99} + \frac{2}{3}\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99} - \frac{8}{3}\,g^{9+}_{88}\,h^{9}_{99}$

Table 17
Continuation of Tab. 16.

$(I,\ S)$	(a,b)	V	$C^{(I,S,0)}_{V,ab}$ charm zero
$(\frac{1}{2},-2)$	$(2,3)$	ρ	$-2\,g^{9+}_{88}\,h^{9}_{99}$
	$(2,4)$	K^*	$-3\,g^{9-}_{88}\,h^{9}_{99}+g^{9+}_{88}\,h^{9}_{99}$
	$(2,7)$	D^*	$\frac{1}{4\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}+\frac{1}{4\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(2,8)$	D^*	$-\sqrt{\frac{3}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}-\sqrt{\frac{3}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(3,3)$	ρ	$4\,g^{9-}_{88}\,h^{9}_{99}$
		ω	$2\,g^{1}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99}$
	$(3,4)$	K^*	$3\,g^{9-}_{88}\,h^{9}_{99}+3\,g^{9+}_{88}\,h^{9}_{99}$
	$(3,7)$	D^*	$-\sqrt{\frac{3}{32}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}-\sqrt{\frac{3}{32}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(3,8)$	D^*	$-\sqrt{\frac{3}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}-\sqrt{\frac{3}{32}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(4,7)$	D^*_s	$-\frac{1}{2\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}-\frac{1}{2\sqrt{6}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(4,8)$	D^*_s	$\frac{1}{2\sqrt{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\frac{1}{2\sqrt{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(4,9)$	D^*	$\frac{1}{4\sqrt{3}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\frac{1}{4\sqrt{3}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(5,7)$	D^*_s	$\sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{1\bar3}+\sqrt{\frac{3}{4}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar31}-\sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar39}-\sqrt{\frac{1}{12}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{9\bar3}$
	$(5,8)$	D^*_s	$-\sqrt{\frac{3}{4}},g^{\bar3}_{86}\,h^{\bar3}_{1\bar3}-\sqrt{\frac{3}{4}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar31}+\sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\sqrt{\frac{1}{12}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(5,9)$	D^*	$\sqrt{\frac{3}{2}}\,g^{\bar3}_{86}\,h^{\bar3}_{1\bar3}+\sqrt{\frac{3}{2}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar31}-\sqrt{\frac{1}{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}-\sqrt{\frac{1}{6}}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(6,7)$	D^*_s	$-\sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{0\bar3}-\sqrt{\frac{1}{8}}\,g^{\bar3}_{8\bar3}\,h^{\bar3}_{\bar30}$
	$(6,8)$	D^*_s	$\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{0\bar3}+\sqrt{\frac{1}{8}}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar30}$
	$(6,9)$	D^*	$-\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{0\bar3}-\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar30}$
	$(7,7)$	ω	$4\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+g^{9}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{\bar3\bar3}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}+g^{9}_{\bar3\bar3}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{\bar3\bar3}\,h^{0}_{\bar3\bar3}$
	$(7,8)$	ω	$g^{9}_{\bar36}*h^{1}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
		ϕ	$g^{9}_{\bar36}\,h^{1}_{\bar3\bar3}$
	$(7,9)$	K^*	$-\sqrt{\frac{1}{2}}\,g^{9}_{\bar36}\,h^{9}_{\bar3\bar3}$
	$(8,8)$	ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+g^{9}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{66}\,h^{9}_{\bar3\bar3}+\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+g^{9}_{66}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
	$(8,9)$	K^*	$-\sqrt{\frac{1}{2}}\,g^{9}_{66}\,h^{9}_{\bar3\bar3}$
	$(9,9)$	ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{9}_{66}\,h^{1}_{\bar3\bar3}+g^{1}_{66}\,h^{9}_{\bar3\bar3}+g^{9}_{66}\,h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
$(\frac{3}{2},-2)$	$(1,1)$	ρ	$-2\,g^{9-}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,2)$	K^*	$-2\,g^{9-}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$
	$(2,2)$	ρ	$-2\,g^{9-}_{88}\,h^{9}_{99}$
		ω	$2\,g^{1}_{88}\,h^{9}_{99}+2\,g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99}$
$(0,-3)$	$(1,1)$	ρ	$3\,g^{9-}_{88}\,h^{9}_{99}-3\,g^{9+}_{88}\,h^{9}_{99}$
		ω	$2\,g^{1}_{88}\,h^{9}_{99}-g^{9-}_{88}\,h^{9}_{99}+g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9-}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$
	$(1,2)$	D^*	$\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{\bar39}+\frac{1}{2}\,g^{\bar3}_{86}\,h^{\bar3}_{9\bar3}$
	$(2,2)$	ω	$4\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{1}_{66}\,h^{9}_{\bar3\bar3}$
		ϕ	$2\,g^{1}_{66}\,h^{1}_{\bar3\bar3}+2\,g^{9}_{66}\,h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{66}\,h^{0}_{\bar3\bar3}$
$(1,-3)$	$(1,1)$	ρ	$-g^{9-}_{88}\,h^{9}_{99}+g^{9+}_{88}\,h^{9}_{99}$
		ω	$2\,g^{1}_{88}\,h^{9}_{99}-g^{9-}_{88}\,h^{9}_{99}+g^{9+}_{88}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{88}\,h^{9}_{99}-2\,g^{9-}_{88}\,h^{9}_{99}-2\,g^{9+}_{88}\,h^{9}_{99}$

Table 18
Continuation of Tab. 17.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(\frac{1}{2},+1)$	$(1,1)$	ω	$-2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{99}-g^{9}_{\bar 3\bar 3}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{99}$
	$(1,2)$	D^*	$\frac{1}{4}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 39}+\frac{1}{4}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{9\bar 3}$
	$(1,3)$	ρ	$\sqrt{3}\,g^{9}_{\bar 36}\,h^{9}_{99}$
	$(2,2)$	ω	$-4\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9-}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{1}_{88}\,h^{9}_{\bar 3\bar 3}-g^{9-}_{88}\,h^{9}_{\bar 3\bar 3}-g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}+2\,g^{9-}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{88}\,h^{0}_{\bar 3\bar 3}$
	$(2,3)$	D^*	$\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{9\bar 3}$
	$(3,3)$	ρ	$2\,g^{9}_{66}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{66}\,h^{9}_{99}-g^{9}_{66}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{66}\,h^{9}_{99}$
$(\frac{3}{2},+1)$	$(1,1)$	ρ	$-g^{9}_{66}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{66}\,h^{9}_{99}-g^{9}_{66}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{66}\,h^{9}_{99}$
$(0,+0)$	$(1,1)$	ρ	$4\,g^{9}_{66}\,h^{9}_{99}$
	$(1,2)$	D^*	$\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{9\bar 3}$
	$(1,4)$	K^*	$-\sqrt{3}\,g^{9}_{\bar 36}\,h^{9}_{99}$
	$(1,5)$	K^*	$\sqrt{3}\,g^{9}_{66}\,h^{9}_{99}$
	$(1,9)$	D^*	$\sqrt{\frac{3}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{3}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(2,2)$	ρ	$\frac{3}{2}\,g^{9-}_{88}\,h^{9}_{\bar 3\bar 3}+\frac{3}{2}\,g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
		ω	$-4\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9-}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}-g^{1}_{88}\,h^{9}_{\bar 3\bar 3}-\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar 3\bar 3}-\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}+2\,g^{9-}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}-g^{1}_{88}\,h^{9}_{\bar 3\bar 3}+g^{9-}_{88}\,h^{9}_{\bar 3\bar 3}-g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{88}\,h^{0}_{\bar 3\bar 3}$
	$(2,3)$	D^*	$\sqrt{\frac{1}{48}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{1}{48}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{9\bar 3}$
	$(2,6)$	K^*	$-\sqrt{3}\,g^{9-}_{88}\,h^{9}_{\bar 3\bar 3}-\sqrt{\frac{1}{3}}\,g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
	$(2,7)$	D^*	$\sqrt{\frac{3}{2}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{1\bar 3}+\sqrt{\frac{3}{2}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 31}-\sqrt{\frac{1}{6}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 39}-\sqrt{\frac{1}{6}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{9\bar 3}$
	$(2,8)$	D^*	$-\frac{1}{2}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{0\bar 3}-\frac{1}{2}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 30}$
	$(3,4)$	K^*	$-\sqrt{3}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{99}$
	$(3,5)$	K^*	$\sqrt{3}\,g^{9}_{\bar 36}\,h^{9}_{99}$
	$(3,6)$	D_s^*	$\frac{1}{6}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 39}+\frac{1}{6}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{9\bar 3}$
	$(3,9)$	D^*	$-\frac{1}{4\sqrt{6}}\,g^{\bar 3}_{\bar 33}\,h^{\bar 3}_{\bar 39}-\frac{1}{4\sqrt{6}}\,g^{\bar 3}_{\bar 33}\,h^{\bar 3}_{9\bar 3}$
	$(4,4)$	ρ	$\frac{3}{2}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{99}-\frac{1}{2}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{99}+g^{9}_{\bar 3\bar 3}\,h^{9}_{99}$
	$(4,5)$	ρ	$\frac{3}{2}\,g^{9}_{\bar 36}\,h^{9}_{99}$
		ω	$-\frac{1}{2}\,g^{9}_{\bar 36}\,h^{9}_{99}$
		ϕ	$-g^{9}_{\bar 36}\,h^{9}_{99}$
	$(4,6)$	D^*	$\sqrt{\frac{1}{48}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{1}{48}}\,g^{\bar 3}_{8\bar 3}\,h^{\bar 3}_{9\bar 3}$
	$(4,9)$	D_s^*	$\sqrt{\frac{1}{32}}\,g^{\bar 3}_{\bar 33}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{1}{32}}\,g^{\bar 3}_{\bar 33}\,h^{\bar 3}_{9\bar 3}$
	$(5,5)$	ρ	$\frac{3}{2}\,g^{9}_{66}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{66}\,h^{9}_{99}-\frac{1}{2}\,g^{9}_{66}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{66}\,h^{9}_{99}+\,g^{9}_{66}\,h^{9}_{99}$
	$(5,6)$	D^*	$-\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{\bar 39}-\sqrt{\frac{3}{16}}\,g^{\bar 3}_{86}\,h^{\bar 3}_{9\bar 3}$
	$(5,9)$	D_s^*	$\sqrt{\frac{1}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 39}+\sqrt{\frac{1}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(6,6)$	ω	$-4\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}-\frac{4}{3}\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}-2\,g^{1}_{88}\,h^{9}_{\bar 3\bar 3}-\frac{2}{3}\,g^{9+}_{88}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{88}\,h^{1}_{\bar 3\bar 3}-\frac{8}{3}\,g^{9+}_{88}\,h^{1}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{88}\,h^{0}_{\bar 3\bar 3}$

Table 19
Continuation of Tab. 18.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(0,+0)$	$(6,7)$	D^*_s	$-\sqrt{\frac{1}{2}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{1\bar3} - \sqrt{\frac{1}{2}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar31} + \sqrt{\frac{1}{18}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{18}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(6,8)$	D^*_s	$\sqrt{\frac{1}{12}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{0\bar3} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar30}$
	$(7,9)$	D^*	$-\sqrt{\frac{3}{4}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{1\bar3} - \sqrt{\frac{3}{4}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar31} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(8,9)$	D^*	$\sqrt{\frac{1}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{0\bar3} + \sqrt{\frac{1}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar30}$
	$(9,9)$	ρ	$-\frac{3}{4}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
		ω	$4\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + g^{9}_{33}\, h^{1}_{\bar3\bar3} + g^{1}_{33}\, h^{9}_{\bar3\bar3} + \frac{1}{4}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
		ϕ	$2\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + g^{9}_{33}\, h^{1}_{\bar3\bar3} + g^{1}_{33}\, h^{9}_{\bar3\bar3} + \frac{1}{2}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{33}\, h^{0}_{\bar3\bar3}$
$(1,+0)$	$(1,2)$	ρ	$-\sqrt{8}\, g^{9}_{\bar36}\, h^{9}_{99}$
	$(1,3)$	D^*	$\frac{1}{4}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} + \frac{1}{4}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(1,4)$	K^*	$g^{9}_{\bar3\bar3}\, h^{9}_{99}$
	$(1,6)$	K^*	$-g^{9}_{\bar36}\, h^{9}_{99}$
	$(1,9)$	D^*	$\sqrt{\frac{1}{32}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{32}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(2,2)$	ρ	$2\, g^{9}_{66}\, h^{9}_{99}$
	$(2,3)$	D^*	$\sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(2,4)$	K^*	$-\sqrt{2}\, g^{9}_{\bar36}\, h^{9}_{99}$
	$(2,6)$	K^*	$\sqrt{2}\, g^{9}_{66}\, h^{9}_{99}$
	$(2,9)$	D^*	$\frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} + \frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(3,3)$	ρ	$-\frac{1}{2}\, g^{9-}_{88}\, h^{9}_{\bar3\bar3} - \frac{1}{2}\, g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		ω	$-4\, g^{1}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9-}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9+}_{88}\, h^{1}_{\bar3\bar3} - g^{1}_{88}\, h^{9}_{\bar3\bar3} - \frac{1}{2}\, g^{9-}_{88}\, h^{9}_{\bar3\bar3} - \frac{1}{2}\, g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar3\bar3} + 2\, g^{9-}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9+}_{88}\, h^{1}_{\bar3\bar3} - g^{1}_{88}\, h^{9}_{\bar3\bar3} + g^{9-}_{88}\, h^{9}_{\bar3\bar3} - g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar3\bar3}$
	$(3,5)$	D^*	$\sqrt{\frac{1}{48}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{48}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(3,7)$	K^*	$-g^{9-}_{88}\, h^{9}_{\bar3\bar3} + g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
	$(3,8)$	D^*	$\sqrt{\frac{3}{2}}\, g^{\bar3}_{86}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{2}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(3,10)$	D^*	$-\frac{1}{2}\, g^{\bar3}_{86}\, h^{\bar3}_{0\bar3} - \frac{1}{2}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar30}$
	$(4,4)$	ρ	$-\frac{1}{2}\, g^{9}_{\bar3\bar3}\, h^{9}_{99}$
		ω	$-2\, g^{1}_{\bar3\bar3}\, h^{9}_{99} - \frac{1}{2}\, g^{9}_{\bar3\bar3}\, h^{9}_{99}$
		ϕ	$2\, g^{1}_{\bar3\bar3}\, h^{9}_{99} + g^{9}_{\bar3\bar3}\, h^{9}_{99}$
	$(4,5)$	K^*	$\sqrt{3}\, g^{9}_{\bar36}\, h^{9}_{99}$
	$(4,6)$	ρ	$-\frac{1}{2}\, g^{9}_{\bar36}\, h^{9}_{99}$
		ω	$-\frac{1}{2}\, g^{9}_{\bar36}\, h^{9}_{99}$
		ϕ	$-g^{9}_{\bar36}\, h^{9}_{99}$
	$(4,7)$	D^*	$-\frac{1}{4}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} - \frac{1}{4}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(4,9)$	D^*_s	$\sqrt{\frac{1}{32}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{32}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(5,6)$	K^*	$-\sqrt{3}\, g^{9}_{66}\, h^{9}_{99}$
	$(5,7)$	D^*_s	$\sqrt{\frac{1}{12}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(5,9)$	D^*	$-\sqrt{\frac{1}{24}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{24}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(6,6)$	ρ	$-\frac{1}{2}\, g^{9}_{66}\, h^{9}_{99}$
		ω	$-2\, g^{1}_{66}\, h^{9}_{99} - \frac{1}{2}\, g^{9}_{66}\, h^{9}_{99}$
		ϕ	$2\, g^{1}_{66}\, h^{9}_{99} + g^{9}_{66}\, h^{9}_{99}$
	$(6,7)$	D^*	$-\frac{1}{4}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \frac{1}{4}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(6,9)$	D^*_s	$\sqrt{\frac{1}{8}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{8}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(7,7)$	ω	$-4\, g^{1}_{88}\, h^{1}_{\bar3\bar3} - 4\, g^{9+}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{1}_{88}\, h^{9}_{\bar3\bar3} - 2\, g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar3\bar3}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar3\bar3}$
	$(7,8)$	D^*_s	$-\sqrt{\frac{3}{2}}\, g^{\bar3}_{86}\, h^{\bar3}_{1\bar3} - \sqrt{\frac{3}{2}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar31} + \sqrt{\frac{1}{6}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{6}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$

Table 20
Continuation of Tab. 19.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(1,+0)$	$(7,10)$	D^*_s	$\frac{1}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{0\bar{3}} + \frac{1}{2}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}0}$
	$(8,9)$	D^*	$-\sqrt{3}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{1\bar{3}} - \sqrt{3}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{\bar{3}1} + \sqrt{\frac{1}{3}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{3}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{9\bar{3}}$
	$(9,9)$	ρ	$\frac{1}{4}\, g^{9}_{33}\, h^{9}_{\bar{3}\bar{3}}$
		ω	$4\, g^{1}_{33}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{33}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{33}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{4}\, g^{9}_{33}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$2\, g^{1}_{33}\, h^{1}_{\bar{3}\bar{3}} + g^{9}_{33}\, h^{1}_{\bar{3}\bar{3}} + g^{1}_{33}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{2}\, g^{9}_{33}\, h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$g^{0}_{33}\, h^{0}_{\bar{3}\bar{3}}$
	$(9,10)$	D^*	$\sqrt{\frac{1}{2}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{0\bar{3}} + \sqrt{\frac{1}{2}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{\bar{3}0}$
$(2,+0)$	$(1,1)$	ρ	$-2\, g^{9}_{66}\, h^{9}_{99}$
$(\frac{1}{2},-1)$	$(1,1)$	ρ	$2\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
	$(1,2)$	ρ	$2\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(1,3)$	K^*	$\sqrt{\frac{3}{2}}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
	$(1,4)$	K^*	$\sqrt{\frac{1}{2}}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(1,5)$	D^*	$\frac{1}{8}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{8}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(1,7)$	D^*	$\frac{1}{8}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{8}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(1,9)$	K^*	$\sqrt{3}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(1,15)$	D^*	$-\frac{\sqrt{3}}{8}\, g^{\bar{3}}_{\bar{3}3}\, h^{\bar{3}}_{\bar{3}9} - \frac{\sqrt{3}}{8}\, g^{\bar{3}}_{\bar{3}3}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$2\, g^{9}_{66}\, h^{9}_{99}$
	$(2,3)$	K^*	$-\sqrt{\frac{3}{2}}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(2,4)$	K^*	$-\sqrt{\frac{1}{2}}\, g^{9}_{66}\, h^{9}_{99}$
	$(2,5)$	D^*	$-\frac{3}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \frac{3}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,7)$	D^*	$\frac{1}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,9)$	K^*	$\sqrt{3}\, g^{9}_{66}\, h^{9}_{99}$
	$(2,15)$	D^*	$\sqrt{\frac{3}{16}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{3}{16}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ω	$2\, g^{1}_{\bar{3}\bar{3}}\, h^{9}_{99} + g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{\bar{3}\bar{3}}\, h^{9}_{99}$
	$(3,4)$	ρ	$-\sqrt{3}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(3,5)$	D^*_s	$-\sqrt{\frac{1}{24}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{24}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,6)$	K^*	$-\sqrt{\frac{3}{2}}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
	$(3,8)$	K^*	$\sqrt{\frac{3}{2}}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(3,14)$	D^*	$\sqrt{\frac{1}{32}}\, g^{\bar{3}}_{\bar{3}3}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{32}}\, g^{\bar{3}}_{\bar{3}3}\, h^{\bar{3}}_{9\bar{3}}$
	$(4,4)$	ρ	$2\, g^{9}_{66}\, h^{9}_{99}$
		ω	$2\, g^{1}_{66}\, h^{9}_{99} + g^{9}_{66}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{66}\, h^{9}_{99}$
	$(4,6)$	K^*	$\sqrt{\frac{9}{2}}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(4,7)$	D^*_s	$-\sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(4,8)$	K^*	$-\frac{3}{\sqrt{2}}\, g^{9}_{66}\, h^{9}_{99}$
	$(4,14)$	D^*	$\sqrt{\frac{3}{8}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{3}{8}}\, g^{\bar{3}}_{63}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,5)$	ω	$-4\, g^{1}_{88}\, h^{1}_{\bar{3}\bar{3}} - \frac{4}{3}\, g^{9+}_{88}\, h^{1}_{\bar{3}\bar{3}} - g^{1}_{88}\, h^{9}_{\bar{3}\bar{3}} - \frac{1}{3}\, g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar{3}\bar{3}} - \frac{8}{3}\, g^{9+}_{88}\, h^{1}_{\bar{3}\bar{3}} - g^{1}_{88}\, h^{9}_{\bar{3}\bar{3}} - \frac{4}{3}\, g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar{3}\bar{3}}$
	$(5,6)$	D^*	$-\frac{1}{24}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{24}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,7)$	ρ	$-g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
	$(5,8)$	D^*	$\frac{1}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{8}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,10)$	K^*	$\sqrt{\frac{3}{2}}\, g^{9-}_{88}\, h^{9}_{\bar{3}\bar{3}} - \sqrt{\frac{1}{6}}\, g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
	$(5,11)$	D^*	$-\sqrt{\frac{1}{8}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{1\bar{3}} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}1} + \sqrt{\frac{1}{72}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{72}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,12)$	D^*	$\sqrt{\frac{9}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{1\bar{3}} + \sqrt{\frac{9}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}1} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(5,13)$	D^*	$\sqrt{\frac{1}{48}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{0\bar{3}} + \sqrt{\frac{1}{48}}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}0}$

Table 21
Continuation of Tab. 20.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(\frac{1}{2},-1)$	$(5,16)$	D^*	$-\sqrt{\frac{3}{16}}\, g^{\bar3}_{86}\, h^{\bar3}_{0\bar3} - \sqrt{\frac{3}{16}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar30}$
	$(6,7)$	D^*	$\frac{1}{8}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} + \frac{1}{8}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(6,9)$	K^*	$\sqrt{3}\, g^{9}_{\bar36}\, h^{9}_{99}$
	$(6,10)$	D^*_s	$\sqrt{\frac{1}{24}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{24}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(6,14)$	D^*_s	$-\sqrt{\frac{1}{48}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{48}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(6,15)$	D^*	$-\frac{1}{8\sqrt{3}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} - \frac{1}{8\sqrt{3}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(7,7)$	ρ	$2\, g^{9-}_{88}\, h^{9}_{\bar3\bar3}$
		ω	$-4\, g^{1}_{88}\, h^{1}_{\bar3\bar3} - 4\, g^{9+}_{88}\, h^{1}_{\bar3\bar3} - g^{1}_{88}\, h^{9}_{\bar3\bar3} - g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar3\bar3} - g^{1}_{88}\, h^{9}_{\bar3\bar3}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar3\bar3}$
	$(7,8)$	D^*	$\frac{1}{8}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} + \frac{1}{8}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(7,10)$	K^*	$-\sqrt{\frac{3}{2}}\, g^{9-}_{88}\, h^{9}_{\bar3\bar3} - \sqrt{\frac{3}{2}}\, g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
	$(7,11)$	D^*	$\sqrt{\frac{9}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{9}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(7,12)$	D^*	$\sqrt{\frac{9}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{9}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(7,13)$	D^*	$-\sqrt{\frac{3}{16}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{0\bar3} + g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar30}$
	$(7,16)$	D^*	$-\sqrt{\frac{3}{16}}\, g^{\bar3}_{86}\, h^{\bar3}_{0\bar3} - \sqrt{\frac{3}{16}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar30}$
	$(8,9)$	K^*	$\sqrt{3}\, g^{9}_{66}\, h^{9}_{99}$
	$(8,10)$	D^*_s	$-\sqrt{\frac{1}{24}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{24}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(8,14)$	D^*_s	$-\sqrt{\frac{1}{12}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{12}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(8,15)$	D^*	$\sqrt{\frac{1}{48}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{48}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(9,9)$	ω	$-2\, g^{1}_{66}\, h^{9}_{99}$
		ϕ	$2\, g^{1}_{66}\, h^{9}_{99} + 2\, g^{9}_{66}\, h^{9}_{99}$
	$(9,10)$	D^*	$-\sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(9,15)$	D^*_s	$\frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} + \frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(10,10)$	ω	$-4\, g^{1}_{88}\, h^{1}_{\bar3\bar3} + 2\, g^{9-}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9+}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{1}_{88}\, h^{9}_{\bar3\bar3} + g^{9-}_{88}\, h^{9}_{\bar3\bar3} - g^{9+}_{88}\, h^{9}_{\bar3\bar3}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9-}_{88}\, h^{1}_{\bar3\bar3} - 2\, g^{9+}_{88}\, h^{1}_{\bar3\bar3}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar3\bar3}$
	$(10,11)$	D^*_s	$-\sqrt{\frac{3}{4}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{1\bar3} - \sqrt{\frac{3}{4}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar31} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{12}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{9\bar3}$
	$(10,12)$	D^*_s	$\sqrt{\frac{3}{4}}\, g^{\bar3}_{86}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{4}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{12}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{12}}\, g^{\bar3}_{86}\, h^{\bar3}_{9\bar3}$
	$(10,13)$	D^*_s	$\sqrt{\frac{1}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{0\bar3} + \sqrt{\frac{1}{8}}\, g^{\bar3}_{8\bar3}\, h^{\bar3}_{\bar30}$
	$(10,16)$	D^*_s	$-\sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{0\bar3} - \sqrt{\frac{1}{8}}\, g^{\bar3}_{86}\, h^{\bar3}_{\bar30}$
	$(11,14)$	D^*_s	$\sqrt{\frac{3}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{24}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{24}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(11,15)$	D^*	$-\sqrt{\frac{3}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{1\bar3} - \sqrt{\frac{3}{8}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar31} + \sqrt{\frac{1}{24}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar39} + \sqrt{\frac{1}{24}}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{9\bar3}$
	$(12,14)$	D^*_s	$\sqrt{\frac{3}{2}}\, g^{\bar3}_{63}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{2}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(12,15)$	D^*	$\sqrt{\frac{3}{2}}\, g^{\bar3}_{63}\, h^{\bar3}_{1\bar3} + \sqrt{\frac{3}{2}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar31} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar39} - \sqrt{\frac{1}{6}}\, g^{\bar3}_{63}\, h^{\bar3}_{9\bar3}$
	$(13,14)$	D^*_s	$-\frac{1}{4}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{0\bar3} - \frac{1}{4}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar30}$
	$(13,15)$	D^*	$\frac{1}{4}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{0\bar3} + \frac{1}{4}\, g^{\bar3}_{\bar33}\, h^{\bar3}_{\bar30}$
	$(14,14)$	ω	$4\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + g^{9}_{33}\, h^{1}_{\bar3\bar3} + 2\, g^{1}_{33}\, h^{9}_{\bar3\bar3} + \frac{1}{2}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
		ϕ	$2\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + g^{9}_{33}\, h^{1}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{33}\, h^{0}_{\bar3\bar3}$
	$(14,15)$	K^*	$\frac{1}{2}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
	$(14,16)$	D^*_s	$-\frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{0\bar3} - \frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar30}$
	$(15,15)$	ω	$4\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + 2\, g^{9}_{33}\, h^{1}_{\bar3\bar3} + g^{1}_{33}\, h^{9}_{\bar3\bar3} + \frac{1}{2}\, g^{9}_{33}\, h^{9}_{\bar3\bar3}$
		ϕ	$2\, g^{1}_{33}\, h^{1}_{\bar3\bar3} + g^{1}_{33}\, h^{9}_{\bar3\bar3}$
		J/Ψ	$g^{0}_{33}\, h^{0}_{\bar3\bar3}$
	$(15,16)$	D^*	$-\frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{0\bar3} - \frac{1}{2}\, g^{\bar3}_{63}\, h^{\bar3}_{\bar30}$

Table 22
Continuation of Tab. 21.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(\frac{3}{2},-1)$	$(1,1)$	ρ	$-g^{9}_{\bar{3}\bar{3}}\,h^{9}_{99}$
	$(1,2)$	ρ	$-g^{9}_{\bar{3}6}\,h^{9}_{99}$
	$(1,3)$	K^*	$-\sqrt{2}\,g^{9}_{\bar{3}6}\,h^{9}_{99}$
	$(1,4)$	D^*	$-\frac{1}{4}\,g^{\bar{3}}_{8\bar{3}}\,h^{\bar{3}}_{\bar{3}9}-\frac{1}{4}\,g^{\bar{3}}_{8\bar{3}}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$-g^{9}_{66}\,h^{9}_{99}$
	$(2,3)$	K^*	$\sqrt{2}\,g^{9}_{66}\,h^{9}_{99}$
	$(2,4)$	D^*	$-\frac{1}{4}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}9}-\frac{1}{4}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ρ	$-g^{9}_{66}\,h^{9}_{99}$
		ω	$2\,g^{1}_{66}\,h^{9}_{99}+g^{9}_{66}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{66}\,h^{9}_{99}$
	$(3,4)$	D_s^*	$-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}9}-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{9\bar{3}}$
	$(4,4)$	ρ	$-g^{9-}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\,g^{1}_{88}\,h^{1}_{\bar{3}\bar{3}}-4\,g^{9+}_{88}\,h^{1}_{\bar{3}\bar{3}}-g^{1}_{88}\,h^{9}_{\bar{3}\bar{3}}-g^{9+}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{88}\,h^{1}_{\bar{3}\bar{3}}-g^{1}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{88}\,h^{0}_{\bar{3}\bar{3}}$
$(0,-2)$	$(1,1)$	ρ	$\frac{3}{2}\,g^{9}_{\bar{3}\bar{3}}\,h^{9}_{99}$
		ω	$2\,g^{1}_{\bar{3}\bar{3}}\,h^{9}_{99}+\frac{1}{2}\,g^{9}_{\bar{3}\bar{3}}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{\bar{3}\bar{3}}\,h^{9}_{99}-g^{9}_{\bar{3}\bar{3}}\,h^{9}_{99}$
	$(1,2)$	ρ	$\frac{3}{2}\,g^{9}_{\bar{3}6}\,h^{9}_{99}$
		ω	$\frac{1}{2}\,g^{9}_{\bar{3}6}\,h^{9}_{99}$
		ϕ	$g^{9}_{\bar{3}6}\,h^{9}_{99}$
	$(1,3)$	D_s^*	$-\frac{1}{4}\,g^{\bar{3}}_{8\bar{3}}\,h^{\bar{3}}_{\bar{3}9}-\frac{1}{4}\,g^{\bar{3}}_{8\bar{3}}\,h^{\bar{3}}_{9\bar{3}}$
	$(1,4)$	K^*	$-\sqrt{6}\,g^{9}_{\bar{3}6}\,h^{9}_{99}$
	$(1,6)$	D^*	$-\frac{1}{4}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9}-\frac{1}{4}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$\frac{3}{2}\,g^{9}_{66}\,h^{9}_{99}$
		ω	$2\,g^{1}_{66}\,h^{9}_{99}+\frac{1}{2}\,g^{9}_{66}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{66}\,h^{9}_{99}-g^{9}_{66}\,h^{9}_{99}$
	$(2,3)$	D_s^*	$\frac{1}{4}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}9}+\frac{1}{4}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,4)$	K^*	$-\sqrt{6}\,g^{9}_{66}\,h^{9}_{99}$
	$(2,6)$	D^*	$\frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9}+\frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ρ	$\frac{3}{2}\,g^{9-}_{88}\,h^{9}_{\bar{3}\bar{3}}-\frac{3}{2}\,g^{9+}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\,g^{1}_{88}\,h^{1}_{\bar{3}\bar{3}}+2\,g^{9-}_{88}\,h^{1}_{\bar{3}\bar{3}}-2\,g^{9+}_{88}\,h^{1}_{\bar{3}\bar{3}}-g^{1}_{88}\,h^{9}_{\bar{3}\bar{3}}+\frac{1}{2}\,g^{9-}_{88}\,h^{9}_{\bar{3}\bar{3}}-\frac{1}{2}\,g^{9+}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{88}\,h^{1}_{\bar{3}\bar{3}}-2\,g^{9-}_{88}\,h^{1}_{\bar{3}\bar{3}}-2\,g^{9+}_{88}\,h^{1}_{\bar{3}\bar{3}}-g^{1}_{88}\,h^{9}_{\bar{3}\bar{3}}-g^{9-}_{88}\,h^{9}_{\bar{3}\bar{3}}-g^{9+}_{88}\,h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{88}\,h^{0}_{\bar{3}\bar{3}}$
	$(3,4)$	D^*	$-\sqrt{\frac{1}{24}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}9}-\sqrt{\frac{1}{24}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,5)$	D^*	$-\sqrt{3}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{1\bar{3}}-\sqrt{3}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}1}+\sqrt{\frac{1}{3}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}9}+\sqrt{\frac{1}{3}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,7)$	D^*	$\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{0\bar{3}}+\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{86}\,h^{\bar{3}}_{\bar{3}0}$
	$(4,6)$	D_s^*	$-\sqrt{\frac{1}{6}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9}-\sqrt{\frac{1}{6}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(5,6)$	D_s^*	$\sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{1\bar{3}}+\sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}1}-\sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9}-\sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(6,6)$	ω	$4\,g^{1}_{33}\,h^{1}_{\bar{3}\bar{3}}+2\,g^{9}_{33}\,h^{1}_{\bar{3}\bar{3}}+2\,g^{1}_{33}\,h^{9}_{\bar{3}\bar{3}}+g^{9}_{33}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$2\,g^{1}_{33}\,h^{1}_{\bar{3}\bar{3}}$
		J/Ψ	$g^{0}_{33}\,h^{0}_{\bar{3}\bar{3}}$
	$(6,7)$	D_s^*	$-\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{0\bar{3}}-\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}0}$

Table 23
Continuation of Tab. 22.

$(I,\ S)$	(a,b)	V	$C^{(I,S,1)}_{V,ab}$ charm one
$(1,-2)$	$(1,2)$	K^*	$-\sqrt{2}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(1,3)$	K^*	$-\sqrt{2}\, g^{9}_{66}\, h^{9}_{99}$
	$(1,4)$	D^*	$-\sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$-\frac{1}{2}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
		ω	$2\, g^{1}_{\bar{3}\bar{3}}\, h^{9}_{99} + \frac{1}{2}\, g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{\bar{3}\bar{3}}\, h^{9}_{99} - g^{9}_{\bar{3}\bar{3}}\, h^{9}_{99}$
	$(2,3)$	ρ	$-\frac{1}{2}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
		ω	$\frac{1}{2}\, g^{9}_{\bar{3}6}\, h^{9}_{99}$
		ϕ	$g^{9}_{\bar{3}6}\, h^{9}_{99}$
	$(2,4)$	D^*_s	$-\frac{1}{4}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{\bar{3}9} - \frac{1}{4}\, g^{\bar{3}}_{8\bar{3}}\, h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ρ	$-\frac{1}{2}\, g^{9}_{66}\, h^{9}_{99}$
		ω	$2\, g^{1}_{66}\, h^{9}_{99} + \frac{1}{2}\, g^{9}_{66}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{66}\, h^{9}_{99} - g^{9}_{66}\, h^{9}_{99}$
	$(3,4)$	D^*_s	$\frac{1}{4}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{\bar{3}9} + \frac{1}{4}\, g^{\bar{3}}_{86}\, h^{\bar{3}}_{9\bar{3}}$
	$(4,4)$	ρ	$-\frac{1}{2}\, g^{9-}_{88}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{2}\, g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\, g^{1}_{88}\, h^{1}_{\bar{3}\bar{3}} + 2\, g^{9-}_{88}\, h^{1}_{\bar{3}\bar{3}} - 2\, g^{9+}_{88}\, h^{1}_{\bar{3}\bar{3}} - g^{1}_{88}\, h^{9}_{\bar{3}\bar{3}} + \frac{1}{2}\, g^{9-}_{88}\, h^{9}_{\bar{3}\bar{3}} - \frac{1}{2}\, g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\, g^{1}_{88}\, h^{1}_{\bar{3}\bar{3}} - 2\, g^{9-}_{88}\, h^{1}_{\bar{3}\bar{3}} - 2\, g^{9+}_{88}\, h^{1}_{\bar{3}\bar{3}} - g^{1}_{88}\, h^{9}_{\bar{3}\bar{3}} - g^{9-}_{88}\, h^{9}_{\bar{3}\bar{3}} - g^{9+}_{88}\, h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{88}\, h^{0}_{\bar{3}\bar{3}}$
$(\frac{1}{2},-3)$	$(1,1)$	ω	$2\, g^{1}_{66}\, h^{9}_{99}$
		ϕ	$-2\, g^{1}_{66}\, h^{9}_{99} - 2\, g^{9}_{66}\, h^{9}_{99}$

Table 24
Continuation of Tab. 23.

$(I,\ S)$	(a,b)	V	$C^{(I,S,2)}_{V,ab}$ charm two
$(0,+1)$	$(1,1)$	ρ	$-\frac{3}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{33}\,h^{9}_{99}-\frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{33}\,h^{9}_{99}+g^{9}_{33}\,h^{9}_{99}$
	$(1,2)$	D^*	$\frac{1}{4}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\frac{1}{4}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(2,2)$	ω	$-4\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-2\,g^{9}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}-g^{9}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{\bar 3\bar 3}\,h^{0}_{\bar 3\bar 3}$
$(1,+1)$	$(1,1)$	ρ	$\frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ω	$-2\,g^{1}_{33}\,h^{9}_{99}-\frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{33}\,h^{9}_{99}+g^{9}_{33}\,h^{9}_{99}$
	$(1,2)$	D^*	$\frac{1}{2}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}+\frac{1}{2}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(2,2)$	ω	$-4\,g^{1}_{66}\,h^{1}_{\bar 3\bar 3}-2\,g^{9}_{66}\,h^{1}_{\bar 3\bar 3}-2\,g^{1}_{66}\,h^{9}_{\bar 3\bar 3}-g^{9}_{66}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar 3\bar 3}$
$(\frac{1}{2},+0)$	$(1,1)$	ρ	$-2\,g^{9}_{33}\,h^{9}_{99}$
	$(1,3)$	K^*	$-\sqrt{\frac{3}{2}}\,g^{9}_{33}\,h^{9}_{99}$
	$(1,4)$	D^*	$\frac{\sqrt{3}}{8}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\frac{\sqrt{3}}{8}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(1,5)$	D^*	$-\frac{1}{4}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}-\frac{1}{4}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(2,3)$	K^*	$-\sqrt{\frac{3}{2}}\,g^{9}_{33}\,h^{9}_{99}$
	$(2,4)$	D^*	$-\frac{\sqrt{3}}{24}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}-\frac{\sqrt{3}}{24}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(2,5)$	D^*	$-\frac{1}{4}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}-\frac{1}{4}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(2,7)$	D^*_s	$\sqrt{\frac{1}{48}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{48}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(2,8)$	D^*_s	$\sqrt{\frac{1}{12}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{12}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(3,3)$	ω	$-2\,g^{1}_{33}\,h^{9}_{99}-g^{9}_{33}\,h^{9}_{99}$
		ϕ	$2\,g^{1}_{33}\,h^{9}_{99}$
	$(3,7)$	D^*	$\sqrt{\frac{1}{32}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{32}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(3,8)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}-\sqrt{\frac{1}{8}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(4,4)$	ω	$-4\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-2\,g^{9}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-g^{1}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}-\frac{1}{2}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-g^{1}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{\bar 3\bar 3}\,h^{0}_{\bar 3\bar 3}$
	$(4,5)$	ρ	$-\sqrt{\frac{3}{4}}\,g^{9}_{\bar 3 6}\,h^{9}_{\bar 3\bar 3}$
	$(4,6)$	D^*	$-\sqrt{\frac{3}{8}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{1\bar 3}-\sqrt{\frac{3}{8}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 1}+\sqrt{\frac{1}{24}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{24}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(4,7)$	K^*	$\frac{1}{2}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}$
	$(4,8)$	K^*	$-\frac{1}{2}\,g^{9}_{\bar 3 6}\,h^{9}_{\bar 3\bar 3}$
	$(4,9)$	D^*	$\frac{1}{4}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{0\bar 3}+\frac{1}{4}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 0}$
	$(5,5)$	ρ	$g^{9}_{66}\,h^{9}_{\bar 3\bar 3}$
		ω	$-4\,g^{1}_{66}\,h^{1}_{\bar 3\bar 3}-2\,g^{9}_{66}\,h^{1}_{\bar 3\bar 3}-g^{1}_{66}\,h^{9}_{\bar 3\bar 3}-\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar 3\bar 3}-g^{1}_{66}\,h^{9}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar 3\bar 3}$
	$(5,6)$	D^*	$-\sqrt{\frac{9}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{1\bar 3}-\sqrt{\frac{9}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 1}+\sqrt{\frac{1}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(5,7)$	K^*	$-\sqrt{\frac{3}{4}}\,g^{9}_{\bar 3 6}\,h^{9}_{\bar 3\bar 3}$
	$(5,8)$	K^*	$\sqrt{\frac{3}{4}}\,g^{9}_{66}\,h^{9}_{\bar 3\bar 3}$
	$(5,9)$	D^*	$\sqrt{\frac{3}{4}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{0\bar 3}+\sqrt{\frac{3}{4}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 0}$
	$(6,7)$	D^*_s	$-\sqrt{\frac{3}{8}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{1\bar 3}-\sqrt{\frac{3}{8}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 1}+\sqrt{\frac{1}{24}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{24}}\,g^{\bar 3}_{\bar 3 3}\,h^{\bar 3}_{9\bar 3}$
	$(6,8)$	D^*_s	$-\sqrt{\frac{3}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{1\bar 3}-\sqrt{\frac{3}{2}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 1}+\sqrt{\frac{1}{6}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{\bar 3 9}+\sqrt{\frac{1}{6}}\,g^{\bar 3}_{63}\,h^{\bar 3}_{9\bar 3}$
	$(7,7)$	ω	$-4\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-g^{9}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-2\,g^{1}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}-\frac{1}{2}\,g^{9}_{\bar 3\bar 3}\,h^{9}_{\bar 3\bar 3}$
		ϕ	$-2\,g^{1}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}-g^{9}_{\bar 3\bar 3}\,h^{1}_{\bar 3\bar 3}$
		J/Ψ	$-g^{0}_{\bar 3\bar 3}\,h^{0}_{\bar 3\bar 3}$

Table 25
Continuation of Tab. 24.

$(I,\ \ S)$	(a,b)	V	$C^{(I,S,2)}_{V,ab}$ charm two
$(\frac{1}{2},+0)$	$(7,8)$	ω	$-g^{9}_{\bar{3}6}\,h^{1}_{\bar{3}\bar{3}} - \frac{1}{2}\,g^{9}_{\bar{3}6}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$g^{9}_{\bar{3}6}\,h^{1}_{\bar{3}\bar{3}}$
	$(7,9)$	D_s^*	$\frac{1}{4}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{0\bar{3}} + \frac{1}{4}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}0}$
	$(8,8)$	ω	$-4\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}} - 2\,g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar{3}\bar{3}}$
	$(8,9)$	D_s^*	$\frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{0\bar{3}} + \frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}0}$
$(\frac{3}{2},+0)$	$(1,1)$	ρ	$g^{9}_{33}\,h^{9}_{99}$
	$(1,2)$	D^*	$\frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} + \frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ρ	$-\frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - 2\,g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar{3}\bar{3}}$
$(0,-1)$	$(1,1)$	ρ	$-\frac{3}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ω	$2\,g^{1}_{33}\,h^{9}_{99} + \frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{33}\,h^{9}_{99} - g^{9}_{33}\,h^{9}_{99}$
	$(1,2)$	K^*	$\sqrt{3}\,g^{9}_{33}\,h^{9}_{99}$
	$(1,3)$	D_s^*	$-\sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(1,4)$	D_s^*	$-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,3)$	D^*	$\frac{1}{4\sqrt{6}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9} + \frac{1}{4\sqrt{6}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,4)$	D^*	$-\sqrt{\frac{1}{24}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{24}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,6)$	D_s^*	$\sqrt{\frac{1}{6}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{6}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ρ	$\frac{3}{4}\,g^{9}_{\bar{3}\bar{3}}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\,g^{1}_{\bar{3}\bar{3}}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{\bar{3}\bar{3}}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{\bar{3}\bar{3}}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{4}\,g^{9}_{\bar{3}\bar{3}}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{\bar{3}\bar{3}}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{\bar{3}\bar{3}}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{\bar{3}\bar{3}}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{2}\,g^{9}_{\bar{3}\bar{3}}\,h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{\bar{3}\bar{3}}\,h^{0}_{\bar{3}\bar{3}}$
	$(3,4)$	ρ	$\frac{3}{4}\,g^{9}_{\bar{3}6}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-g^{9}_{\bar{3}6}\,h^{1}_{\bar{3}\bar{3}} - \frac{1}{4}\,g^{9}_{\bar{3}6}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$g^{9}_{\bar{3}6}\,h^{1}_{\bar{3}\bar{3}} + \frac{1}{2}\,g^{9}_{\bar{3}6}\,h^{9}_{\bar{3}\bar{3}}$
	$(3,5)$	D^*	$\sqrt{\frac{3}{4}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{1\bar{3}} + \sqrt{\frac{3}{4}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}1} - \sqrt{\frac{1}{12}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{12}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,6)$	K^*	$g^{9}_{\bar{3}6}\,h^{9}_{\bar{3}\bar{3}}$
	$(3,7)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{0\bar{3}} - \sqrt{\frac{1}{8}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}0}$
	$(4,4)$	ρ	$\frac{3}{4}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ω	$-4\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{4}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}} - g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}} - \frac{1}{2}\,g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar{3}\bar{3}}$
	$(4,5)$	D^*	$-\sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{1\bar{3}} - \sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}1} + \sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(4,6)$	K^*	$g^{9}_{66}\,h^{9}_{\bar{3}\bar{3}}$
	$(4,7)$	ϕ	$\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{0\bar{3}} + \sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}0}$
	$(5,6)$	D_s^*	$-\sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{1\bar{3}} - \sqrt{3}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}1} + \sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{3}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(6,6)$	ω	$-4\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - 2\,g^{1}_{66}\,h^{9}_{\bar{3}\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{\bar{3}\bar{3}} - 2\,g^{9}_{66}\,h^{1}_{\bar{3}\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{\bar{3}\bar{3}}$
	$(6,7)$	D_s^*	$\sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{0\bar{3}} + \sqrt{\frac{1}{2}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}0}$
$(1,-1)$	$(1,2)$	K^*	$g^{9}_{33}\,h^{9}_{99}$
	$(1,3)$	D^*	$\sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9} + \sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(1,4)$	D^*	$-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$

Table 26
Continuation of Tab. 25.

$(I,\ \ S)$	(a,b)	V	$C_{V,ab}^{(I,S,2)}$ charm two
$(1,-1)$	$(2,2)$	ρ	$\frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ω	$2\,g^{1}_{33}\,h^{9}_{99} + \frac{1}{2}\,g^{9}_{33}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{33}\,h^{9}_{99} - g^{9}_{33}\,h^{9}_{99}$
	$(2,3)$	D^*_s	$-\sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{32}}\,g^{\bar{3}}_{\bar{3}3}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,4)$	D^*_s	$-\sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} - \sqrt{\frac{1}{8}}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(3,3)$	ρ	$-\frac{1}{4}\,g^{9}_{\bar{3}3}\,h^{9}_{3\bar{3}}$
		ω	$-4\,g^{1}_{\bar{3}3}\,h^{1}_{3\bar{3}} - g^{9}_{\bar{3}3}\,h^{1}_{3\bar{3}} - g^{1}_{\bar{3}3}\,h^{9}_{3\bar{3}} - \frac{1}{4}\,g^{9}_{\bar{3}3}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{\bar{3}3}\,h^{1}_{3\bar{3}} - g^{9}_{\bar{3}3}\,h^{1}_{3\bar{3}} - g^{1}_{\bar{3}3}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{\bar{3}3}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{\bar{3}3}\,h^{0}_{3\bar{3}}$
	$(3,4)$	ρ	$-\frac{1}{4}\,g^{9}_{\bar{3}6}\,h^{9}_{3\bar{3}}$
		ω	$-g^{9}_{\bar{3}6}\,h^{1}_{3\bar{3}} - \frac{1}{4}\,g^{9}_{\bar{3}6}\,h^{9}_{3\bar{3}}$
		ϕ	$g^{9}_{\bar{3}6}\,h^{1}_{3\bar{3}} + \frac{1}{2}\,g^{9}_{\bar{3}6}\,h^{9}_{3\bar{3}}$
	$(4,4)$	ρ	$-\frac{1}{4}\,g^{9}_{66}\,h^{9}_{3\bar{3}}$
		ω	$-4\,g^{1}_{66}\,h^{1}_{3\bar{3}} - g^{9}_{66}\,h^{1}_{3\bar{3}} - g^{1}_{66}\,h^{9}_{3\bar{3}} - \frac{1}{4}\,g^{9}_{66}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{3\bar{3}} - g^{9}_{66}\,h^{1}_{3\bar{3}} - g^{1}_{66}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{66}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{3\bar{3}}$
$(\frac{1}{2},-2)$	$(1,1)$	ω	$2\,g^{1}_{33}\,h^{9}_{99} + g^{9}_{33}\,h^{9}_{99}$
		ϕ	$-2\,g^{1}_{33}\,h^{9}_{99}$
	$(1,2)$	D^*_s	$-\frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{\bar{3}9} - \frac{1}{2}\,g^{\bar{3}}_{63}\,h^{\bar{3}}_{9\bar{3}}$
	$(2,2)$	ω	$-4\,g^{1}_{66}\,h^{1}_{3\bar{3}} - g^{1}_{66}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{66}\,h^{1}_{3\bar{3}} - 2\,g^{9}_{66}\,h^{1}_{3\bar{3}} - g^{1}_{66}\,h^{9}_{3\bar{3}} - g^{9}_{66}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{66}\,h^{0}_{3\bar{3}}$
$(I,\ \ S)$	(a,b)	V	$C_{V,ab}^{(I,S,3)}$ charm three
$(\frac{1}{2},+1)$	$(1,1)$	ω	$-4\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}} - 2\,g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{33}\,h^{0}_{3\bar{3}}$
$(0,+0)$	$(1,1)$	ρ	$-\frac{3}{4}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ω	$-4\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{4}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{33}\,h^{0}_{3\bar{3}}$
	$(1,2)$	K^*	$-\sqrt{\frac{1}{2}}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
	$(2,2)$	ω	$-4\,g^{1}_{33}\,h^{1}_{3\bar{3}} - 2\,g^{9}_{33}\,h^{1}_{3\bar{3}} - 2\,g^{1}_{33}\,h^{9}_{3\bar{3}} - g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{33}\,h^{1}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{33}\,h^{0}_{3\bar{3}}$
$(1,+0)$	$(1,1)$	ρ	$\frac{1}{4}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ω	$-4\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{4}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ϕ	$-2g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{9}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{33}\,h^{0}_{3\bar{3}}$
$(\frac{1}{2},-1)$	$(1,1)$	ω	$-4\,g^{1}_{33}\,h^{1}_{3\bar{3}} - 2\,g^{9}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}} - \frac{1}{2}\,g^{9}_{33}\,h^{9}_{3\bar{3}}$
		ϕ	$-2\,g^{1}_{33}\,h^{1}_{3\bar{3}} - g^{1}_{33}\,h^{9}_{3\bar{3}}$
		J/Ψ	$-g^{0}_{33}\,h^{0}_{3\bar{3}}$

Table 27

Continuation of Tab. 26.

References

[1] S.J. Brodsky, I. Schmidt and G.F. de Teramond, Phys. Rev. Lett. **64** (1990) 1011.

[2] A.B. Kaidalov and P.E. Volkovitsky, Phys. Rev. Lett. **69** (1992) 3155.

[3] C. Gobbi, D.O. Riska and N.N. Scoccola, Phys. Lett. **B 296** (1992) 166.

[4] L.G. Landsberg, Phys. Atom. Nucl. **57** (1994) 2127.

[5] T. Amirzadeh et al., Phys. Lett. **B 89** (1979) 125.

[6] V.M. Karnaukhov et al., Phys. Lett. **B 281** (1991) 148.

[7] M.F.M. Lutz and E.E. Kolomeitsev, Nucl. Phys. **A 730** (2004) 110.

[8] M.F.M. Lutz and E. E. Kolomeitsev, Nucl. Phys. **A 755** (2005) 29c.

[9] E.E. Kolomeitsev and M.F.M. Lutz, Phys. Lett. **B 585** (2004) 243.

[10] J. Hofmann and M.F.M. Lutz, Nucl. Phys. **A 733** (2004) 142.

[11] M.F.M. Lutz and E. E. Kolomeitsev, Nucl. Phys. **A 700** (2002) 193.

[12] M.F.M. Lutz, Gy. Wolf and B. Friman, Nucl. Phys. **A 706** (2002) 431.

[13] M.F.M. Lutz and E.E. Kolomeitsev, Nucl. Phys. **A 730** (2004) 392.

[14] C. García-Recio, M.F.M. Lutz and J. Nieves, Phys. Lett. **B 582** (2004) 49.

[15] E.E. Kolomeitsev and M.F.M. Lutz, Phys. Lett. **B 585** (2004) 243.

[16] Ch. Hong-Mo and H. Högaasen, Z. Phys. **C 7** (1980) 25.

[17] M. Rho, D.O. Riska and N.N. Scoccola, Z. Phys. **A 341** (1992) 343.

[18] D.-P. Min, Y. Oh, B.-Y. Park and M. Rho, Int. J. Mod. **E 4** (1995) 47.

[19] Y. Oh and H. Kim, Phys. Rev. **D 70** (2004) 094022.

[20] S. Weinberg, Phys. Rev. **166** (1968) 1568.

[21] H.W. Wyld, Phys. Rev. **155** (1967) 1649.

[22] R.H. Dalitz, T.C. Wong and G. Rajasekaran, Phys. Rev. **153** (1967) 1617.

[23] P.B. Siegel and W. Weise, Phys. Rev. C **38** (1988) 2221.

[24] M. Bando et al., Phys. Rev. Lett. **54** (1985) 1215.

[25] S. Eidelman et al., Phys. Lett. **B 592** (2004) 1.

[26] M. Maston et al. (SELEX Collaboration), Phys. Rev. Lett. **89** (2002) 112001.

[27] J.S. Russ, AIP Conf. Proc. **717** (2004) 507.

[28] J. Engelfried, Nucl. Phys. **A 752** (2005) 121c.

[29] J.G. Körner, M. Krämer and D. Pirjol, Prog. Part. Nucl. Phys. **33** (1994) 787.

[30] K. Kawarabayashi and M. Suzuki, Phys. Rev. Lett. **16** (1966) 255.

[31] Riazuddin and Fayyazuddin, Phys. Rev. **147** (1966) 1071.

[32] D. Djukanovic et al., Phys. Rev. Lett. **93** (2004) 122002.

[33] G. Höhler, πN NewsLetter **9** (1993) 1.

[34] V.S. Mathur, S. Okubo and S. Borchardt, Phys. Rev. **D 11** (1975) 2572.

[35] R. Mizuk et al. (BELLE Collaboration), Phys. Rev. Lett. **94** (2005) 122002.

[36] L.A. Copley, N. Isgur and G. Karl, Phys. Rev. **D 20** (1979) 768.

[37] N. Mathur, R. Lewis and R. M. Woloshyn, Phys. Rev. **D 66** (2002) 014502.

[38] R. Dashen, E. Jenkins and A.V. Manohar, Phys. Rev. **D 49** (1994) 4713.

[39] S. Okubo, Phys. Lett. **5** (1963) 165; G. Zweig, CERN Reports TH-401, TH-412 (1964), unpublished; J. Iiuzuka, Prog. Theor. Part. Sci. **37** (1966) 21.

[40] H.J. Lipkin, Phys. Lett. **B 195** (1987) 484.

[41] M. Genovese, J.-M. Richard, F.L. Stancu and S. Pepin, Phys. Lett. **B 425** (1998) 171.

[42] H1 Collaboration, Phys. Lett. **B 588** (2004) 17.

[43] I.W. Stewart, M.E. Wessling and M.B. Wise, Phys. Lett. **B 590** (2004) 185.

[44] H. Kim, S.H. Lee and Y. Oh, Phys. Lett. **B 595** (2004) 293.

[45] M.E. Wessling, Phys. Lett. **B 603** (2004) 152.

[46] D. Pirjol and C. Schat, Phys. Rev. **D 71** (2005) 036004.

[47] P. Bicudo, Phys. Rev. **D 71** (2005) 011501 (R).

[48] M. Artuso et. al. (CLEO Collaboration), Phys. Rev. Lett. **86** (2001) 4479.